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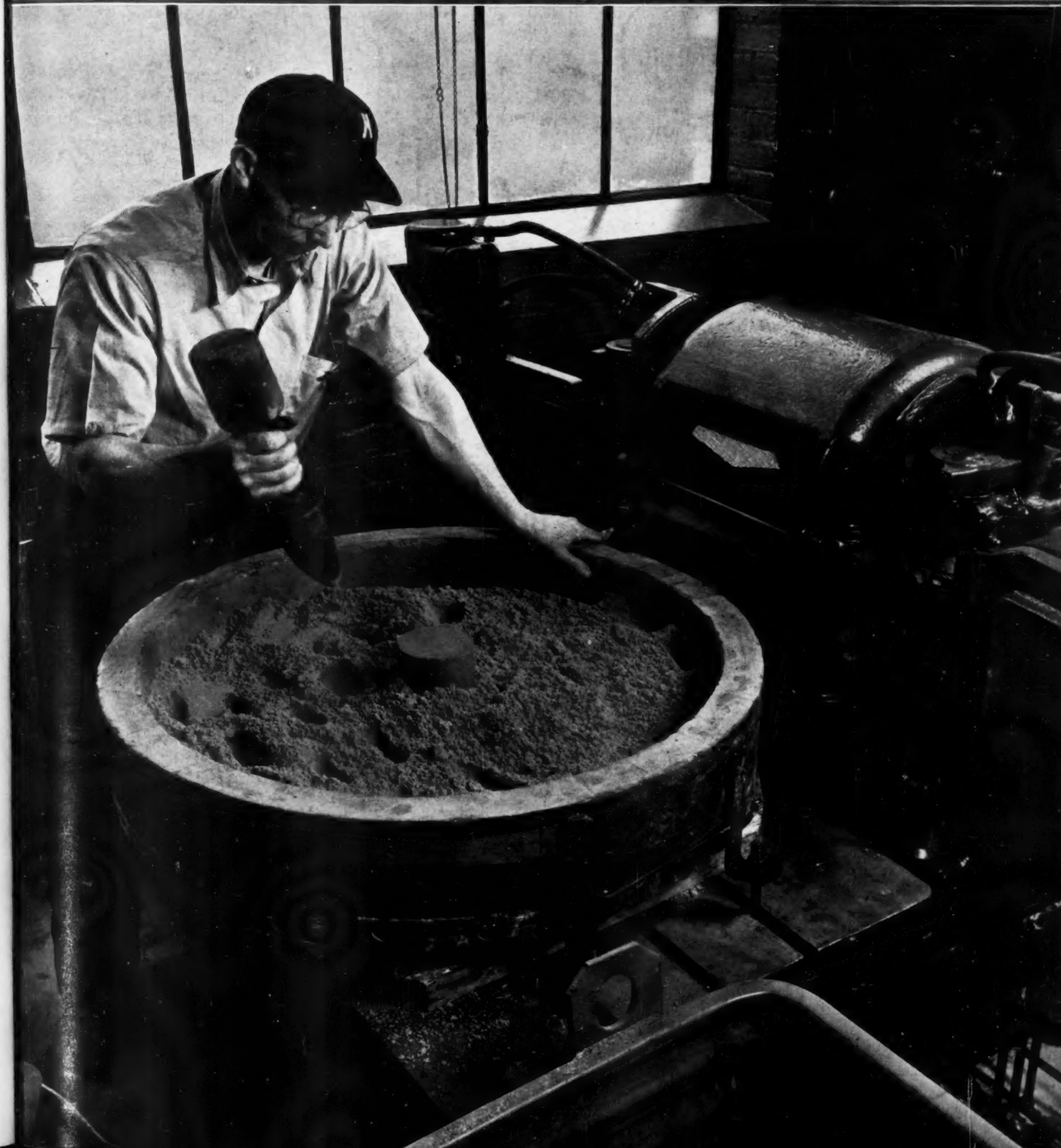
MECHANICAL ENGINEERING

SEPTEMBER 1944



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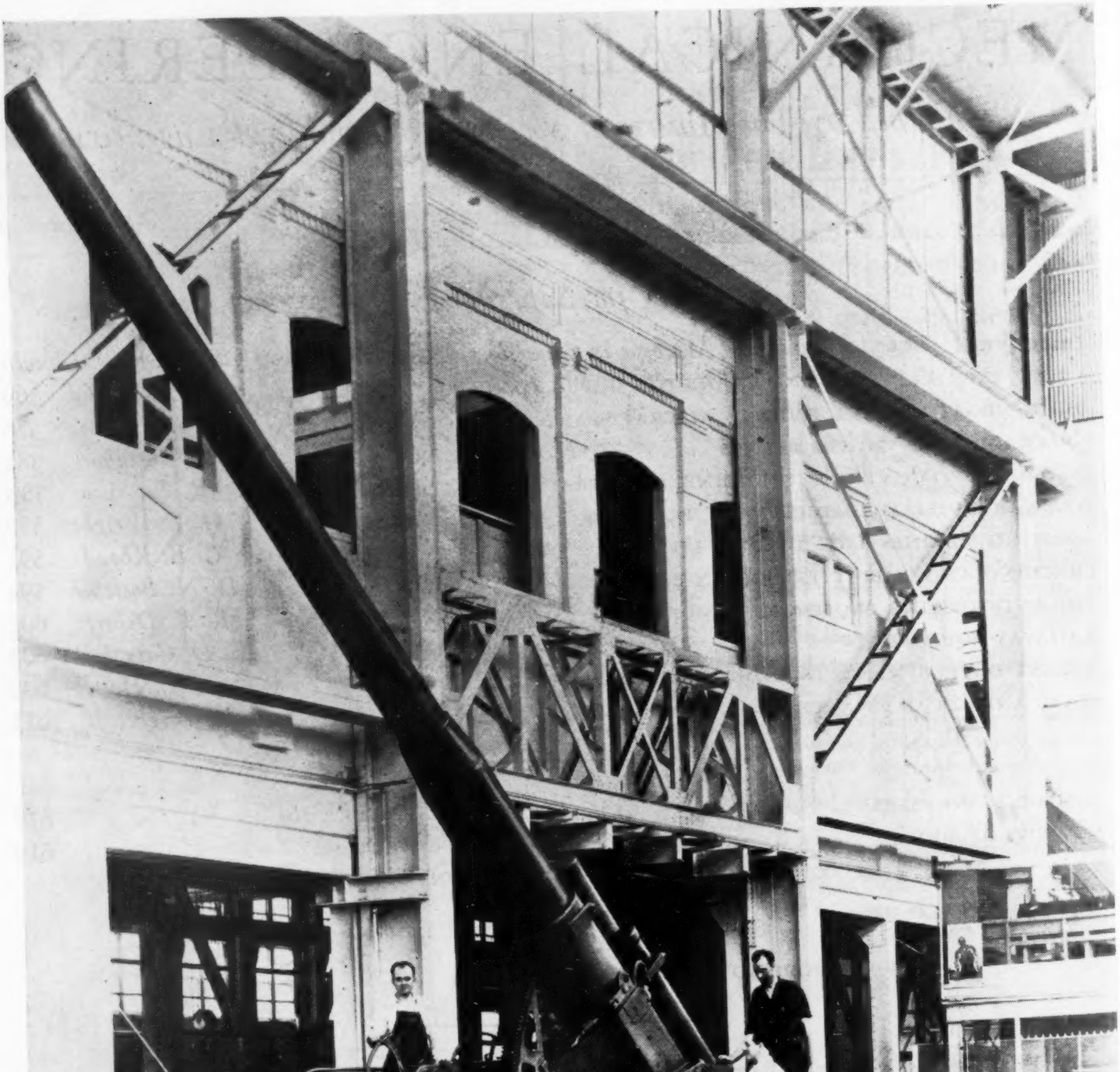

Eight-Inch Mobile Gun

(Close co-ordination of operations of two York, Pa., companies with contiguous plants made possible the production of this 8-inch gun, shown here in final assembly in the S. Morgan Smith plant at York. Partner in the unique enterprise, involving an assembly line alternately weaving its way in and out of the two plants, is the York Corporation.)

A New Type SCREW-LUFFING CRANE *for* SHIPBUILDING

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THIS paper describes one of the important developments in shipyard cranes in recent years and has special reference to the use of screw-luffing. The modern trend toward larger and larger fabricated assemblies as a more economical and faster method of ship construction has required larger-capacity crane equipment with more precise control of heavy and awkward loads.

The use of large screws for transmission of power is not new in American practice and various applications of the power screw are readily called to mind. Among these may be mentioned their common use as "screw downs" in connection with rolling mills, their use in testing equipment where smooth even travel and power transmission are required, and their use in lathes and other equipment where travel again must be extremely smooth and accurate.

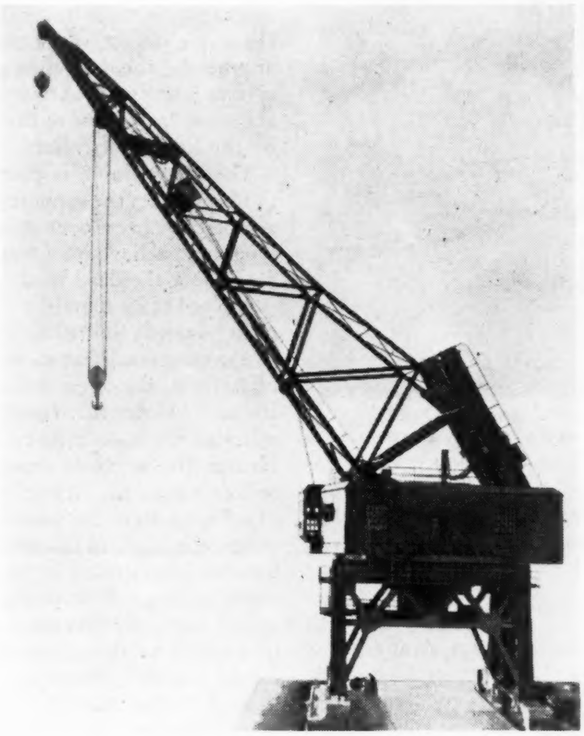


FIG. 1 GENERAL VIEW OF 75 GROSS TON SCREW-LUFFING FULL REVOLVING SHIPYARD CRANE

As a component of a crane or other piece of material-handling equipment, the use of power screws is also not new. As far as European practice is concerned, the screw has been very commonly used as the boom-luffing or boom-hoisting medium on both large and small cranes. In England its use has largely been confined to the more massive cranes, principally those in the range of 75 ton capacity and upward, and particularly it has been employed on the large floating cranes built both by the British and on the Continent.

American practice on the other hand has largely utilized rope-luffing, and the percentage of cranes employing screw-luffing in the United States is extremely low. The screw has been used on large floating cranes and there are also instances of installations on smaller traveling cranes, usually those in the general range of 50 ton capacity.

It is not proposed to theorize on why this application is so relatively infrequent in this country, but rather the purpose of this paper is to describe generally a new arrangement for screw-luffing cranes as developed by our company during recent years and to indicate the results obtained.

Fig. 1 shows a general view of the largest of the three sizes of screw-luffing, full revolving, shipyard cranes which have been manufactured thus far and which utilize the screw arrangement to be discussed. The principal dimensions and basic operating data for this crane are given in Table 1.

Briefly stated, luffing of the boom is accomplished by means of two power screws concealed beneath the structural framework shown between the boom and the rear of the rotating structure and designated as the screw frames. The boom and the lower end of the screws are pin-connected to the two ends of a longitudinal truss system which projects through the machinery-house roof at the required points, and which are designed to carry all forces from the boom thrust and the screw tension.

The entire crane is of welded construction and has a weight in operating condition, but without load, of 830 tons of which 200 tons is counterweight in the rear of the rotating structure. The crane is of the balanced-deck type, that is, the center of gravity of the rotating structure is well within the roller circle under all operating conditions. In order to visualize the size of the component parts and particularly the parts of the screw arrangement, a comparison may be drawn with the man in the door of the rotating structure and on the dock, Fig. 1.

Electric operation is used throughout, 230-v direct current being taken from conductor rails along one side of the crane runway and transmitted to the rotating structure by means of rotary collectors.

Fig. 2 was taken from the rear of the crane in order to show more clearly the two screw frames as well as the location of the operating machinery. The rear wings, in conjunction with the extension of the rotating platform, are used to house the counterweight for the rotating structure. This arrangement

TABLE 1 PRINCIPAL DIMENSIONS AND OPERATING DATA FOR SCREW-LUFFING CRANE

Main hoist capacity at 104 ft 6 in. radius, gross tons	75
Auxiliary hoist capacity at 122 ft 6 in. radius, gross tons	15
Main hoist speed, fpm	18
Auxiliary hoist speed, fpm	78
Boom-luffing speed from 104 ft 6 in. radius to 60 ft radius with full load on hook	$3^1/_4$ min
Rotate speed with full load on hook	$2^1/_2$ min
Travel speed with full load on hook, fpm	150
Length of boom to main block	100 ft 10 in.
Length of boom to auxiliary block	123 ft 6 in.
Height from rail to boom-foot pin	57 ft
Track rail centers	40 ft

Contributed by the Materials Handling Division and presented at the Semi-Annual Meeting, Pittsburgh, Pa., June 17–19, 1944, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

FIG. 2 PLAN VIEW OF CRANE, SHOWING SCREW FRAMES AND LOCATION OF SCREW-OPERATING MACHINERY

also provides concealment for the lower end of the screw frame and screws and gives the entire rotating structure a conventional appearance.

OPERATION OF LUFFING MECHANISM

A diagrammatic sketch of the screw-luffing arrangement utilized on this crane is shown in Fig. 3. The sketch shows a single screw although actually two such screws are used. The driving mechanism is mounted on the screw frame and is illustrated by the motor, pinion, and gear located in the center of the screw. Two nuts are employed, one attached to the boom by the links *F* and the other attached to the rotating platform by similar links. The screw is provided with right-hand and left-hand threads, and rotation of the screw causes the two nuts to approach one another or to recede from one another thus raising or lowering the boom. The lower nut is fixed in position to the rotating-platform trusses, and as the screw turns and the boom is raised several motions will take place:

1 The screw will travel back through the lower nut.

2 The upper nut will travel along the screw toward the lower nut.

3 The drive machinery will travel back toward the lower nut but will remain midway between the two nuts.

4 The angularity of the screw and screw frame with respect to the horizontal will change. This angularity will be least with the boom in low position, as shown in Fig. 3, and greatest with the boom in high position corresponding to the load block at minimum radius.

This arrangement differs from that which has been used in a great many applications where a single nut is employed and where the screw is turned by machinery located near one end of the screw. For applications of this type, the only traveling item is the single nut, although the angularity of the screw changes with the position of that nut.

The screw frame, shown in Figs. 1 and 2, has been almost entirely cut away in Fig. 3, but this figure still illustrates how the screw frame encompasses the entire assembly. There is indicated a small portion of the side member of the screw frame adjacent to the two ends. Each of the two sides of the screw frame is provided with two machined paths one of which is part way up the web and the other of which is on the inside of the bottom flange. Guide rollers are provided on extended pins at both ends of all links and these rollers are fitted between the two machined paths of the side frames. Thus the weight of the entire screw frame is carried on the guide rollers with those rollers which are at the point of attachment of the links to the crane structure and boom carrying this load. The driving mechanism is made integral with the screw frame, and therefore the frame and screw are maintained in constant relation to one another by the driving-machinery housing. This results in a system wherein the screw nuts travel along parallel guides in the screw frame, and at the same time the screw frame is carried by the link guide rollers.

The screw frame is provided to perform several functions: (1) It provides the support for the driving machinery and forms a protective hood over the screw. (2) It serves to support the screw and relieve it of bending stresses and deflections which arise from the dead load of the screw. Because the screw is supported at its center by the screw frame, the center deflection of the screw is limited by the center deflection of the frame, and as the structural frame can be made with any required degree of stiffness, the screw deflection can be kept within reasonable limits. (3) Another function provided by the frame is that of relieving the links from twist due to the tendency of the nut to turn as the screw is rotated. The outermost pairs of guide rollers carry the frame weight, and the innermost pairs of rollers deliver the twisting force to the screw frame which is sufficiently rigid to transmit this force to the structure. (4) A final use for the frame is that of providing a safety link in case of screw failure. Assuming a tension rupture of the screw, this would likely occur in the tension section between the two nuts, in which case the two ends of the screw outside of the nuts would transmit a compressive load to special safety castings located at the ends of the screw frame, and the frame itself would then serve as the tension link to hold the boom in place.

Further shown in Fig. 3 is the detail of the arrangement at the nuts and links. The bronze nut *A* is threaded on its inner surface to match the threading of the screw and is stepped on its outer surface to transmit its load to a steel male trunnion *B* into which it is pressed. The male trunnion in turn has a clearance fit inside of the steel female trunnion *C* which carries the arms to which are attached the links.

DESIGN AND SHOP-ASSEMBLY METHODS

In the design of any mechanical assembly such as used in this

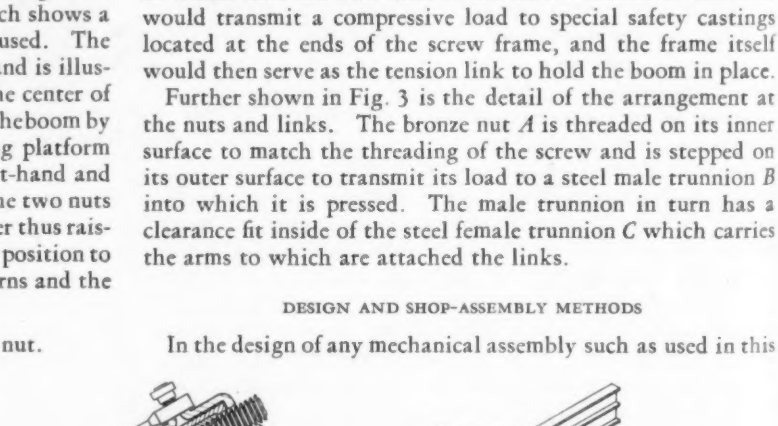


FIG. 3 DIAGRAM OF SCREW-LUFFING ARRANGEMENT

screw-luffing arrangement, at very early stages it is necessary to consider the accuracy of manufacture and alignment which can be anticipated in the shops and also in the field after erection. Ideal conditions would require that the axes of the pins connecting the boom to the upper links, the boom foot to the rotating-platform trusses, and the lower links to the rotating-platform trusses, be in straight lines without offsets and that these same axes be parallel to one another, in order that the two screws share the load equally at all positions of the boom. Further the lengths of all links should be identical.

For this reason shop methods were carefully planned to obtain the greatest accuracy. Large structural assemblies were made and fully shop-welded before the boring of pinholes was carried out. Typical of this type of assembly is the end portal frame for the boom. This single structural assembly carries pinholes for the two boom-foot pins and also holes for the four link pins for attachment of the upper nuts for both screws. It was thus possible to bore these holes in the machine shop to the required parallelism and concentricity. Similarly the front and rear frames for the two rotating structure trusses were each made in single pieces.

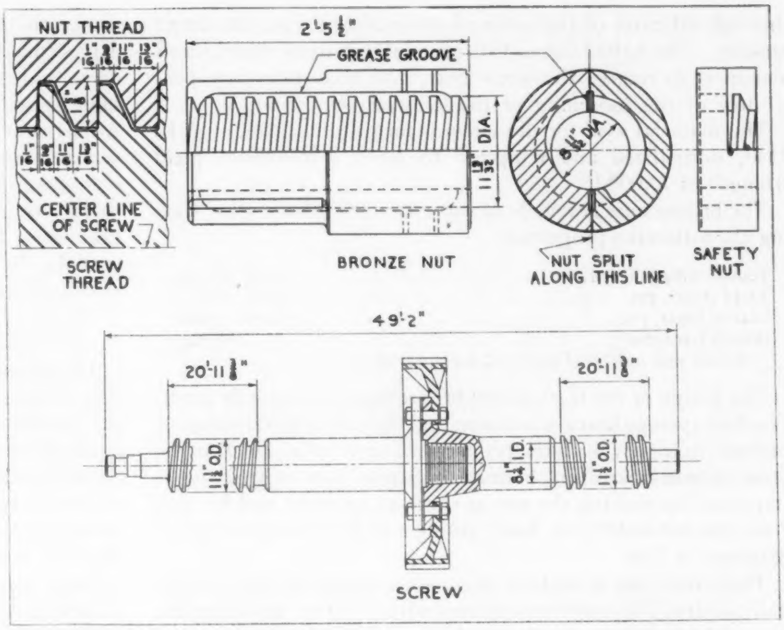


FIG. 5 DETAILS OF SCREW DESIGNED FOR CRANE SHOWN IN FIG. 1

In the field, careful measurements were made to align the several sets of pinholes in order again to assure these holes being parallel to one another. In addition, flexibility with respect to possible misalignment is provided in the mechanical arrangement.

Vertical readjustment is permitted by the use of the links in place of pivoting the trunnions directly at the points of attachment to the structure and boom. Provision for horizontal readjustment was made by providing vertical rocker pins between the male and female trunnions at the point where the male trunnion bears on the female trunnion. The clearance provided between the trunnions permits of a horizontal rocking motion between the two trunnions so that the male trunnion can adapt itself to the axis of the screw while the female trunnion can take the position required by minor errors in links or pin alignment.

Supplementing Fig. 3, which is strictly diagrammatic, is Fig. 4 which is an isometric drawing of a single-screw unit and shows more clearly the entire arrangement. This drawing will serve somewhat better to indicate the relation of all of the component parts which have been mentioned heretofore.

In approaching the determination of the details of design of a screw-luffing mechanism, it is necessary first to consider the practical geometrical arrangement which results from the layout of the crane. Obviously, the tensile stress and consequently also the torque in the screw will decrease as the effective lever arm with respect to the boom-foot pin is increased. On the other hand, as these stresses decrease, the length of the screw and the required nut travel will increase. Practical considerations require that an arrangement be selected which will utilize a screw having a diameter in proportion to its length such that it may be safely and easily handled during the shop processing without danger of injury by bending. The length also must be considered with relation to lathe equipment available for the cutting, and further must be such that the screw frame does not project beyond the required tail-swing clearance line. For the crane shown in Fig. 1, the arrangement selected produced a maximum static direct tension of 327,000 lb in each screw. The screw designed to take this load and shown in Fig. 5 has a root diameter of $8^1/_4$ in. and an outside diameter of $11^1/_2$ in. The pitch selected was $2^1/_8$ in., which resulted in a nut $29^1/_2$ in. long, having an average bearing pressure of approximately 600 psi on the thread, based on the net projected area in contact between the screw and the nut. This value was used because of the conditions under which crane screws must of necessity operate in outdoor service. A modified buttress type of thread is used, the dimensions of which are shown in Fig. 5. The relief provided on the working surface of the threads tends to center the screw in the bronze nut and is slightly more easily machined.

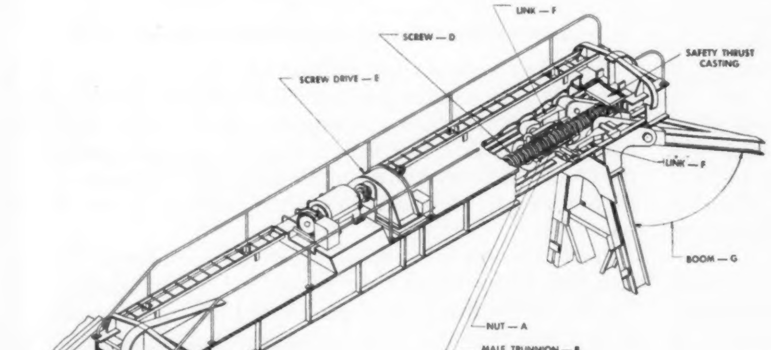


FIG. 4 ISOMETRIC DRAWING OF A SINGLE-SCREW UNIT

The screw has a length over-all of 49 ft 2 in. and as originally detailed was to have been made in a single piece. However, lathe capacity, which was contemplated would be available for this work, was required elsewhere in the war program and the details were altered to permit machining of each screw in two halves. This connection was arranged as also shown in Fig. 5. Sufficient section is provided

through all parts of the screwed connection to take the direct tension. The bolted connection takes all torsional shear, forms a support to receive the screw gear, and eliminates any possibility of the loosening of the screwed connection.

The material used for the screw is forged nickel steel S.A.E. 2340, normalized and tempered to have a minimum yield strength of 70,000 lb.

The bronze nuts are made of superstrength bronze alloy having the following properties:

Tensile strength, psi	90000–115000
Yield point, psi	45000–68000
Elastic limit, psi	38000–50000
Brinell hardness	185–240

Actual test indicated a Brinell hardness of 220

The design of the teeth in the bronze nut is necessarily predicated on average bearing pressure, and the actual distribution of pressure may vary with the proportions of the nut as well as the class of workmanship obtained. Distribution of pressure is improved by making the nut as short as possible, and for this crane the nut is $29^1/_2$ in. long, giving a ratio of length-to-pitch diameter of 2.99.

The bronze nut is made in two halves, being split longitudinally to divide it into two semicyclindrical parts. Dividing the nut in this way permits the machining of the details necessary for the effective lubrication of the screw and nut. A grease groove is cut along the length of the two halves of the nut at the partings, interrupting the continuity of the threads. The ends of each of these threads is tapered off and slightly rounded. In practice, grease is introduced under pressure into the reservoir formed by the longitudinal grooves, and during rotation the wedge-shaped clearance at the ends of the threads serves to feed the grease to the screw. Extreme-pressure lubricants are used, being forced into the nut by pressure gun as well as being brush-applied to the screw itself.

A steel safety nut is attached to the bronze nut by tap bolts in such relation that, when the threads of the bronze nut are in contact with the threads of the screw, the threads of the safety nut have a definite clearance with respect to the threads of the screw. A portion of the safety nut is cut out as shown, permitting this clearance to be measured. These repeated measurements taken over definite intervals of time furnish information as to the rate of wear on the bronze nut. The safety nut then furnishes not only safety against failure by stripping of the bronze nut but also a means of measuring whether the rate of wear is such as should be expected.

The male trunnions were cast of 0.30–0.40 C steel, and the female trunnions were cast of alloy steel having a tensile strength of 90,000 psi. This latter trunnion is subject to high stress points adjacent to the link arms and at the points where the male trunnions bear on the bottom pins. The design requires thick sections and in order to insure sound castings all critical areas were examined by the use of the gamma ray.

Fig. 6 shows typical screws and frames in the course of assembly in the shop. These parts are from a smaller crane, the screws being 35 ft long with a root diameter of $6^1/_2$ in., and were machined in one length. They were found to be rather flexible and care had to be exercised in handling during the various shop operations.

The operating mechanisms for the two screws are conventional two-reduction drives, the first reduction having herringbone gears and the second being spur gearing, all enclosed in welded cases. The high-speed gearing is provided with antifriction bearings, while the screw itself is supported on bronze bearings. A chain-driven lubricating-oil pump is used to supply oil to the bearings and to spray oil on the high-speed gears. The low-speed gears are lubricated by running in oil in the bottom of the gear case at all times. All parts, therefore, receive lubrication regardless of the position of the driving mechanism.

A feature of the drive for the 75-ton crane, occasioned by the use of two screws, is the provision of a cross-shaft tying the drives together. An individual 100-hp motor was used for each drive, and as it is imperative that both screws turn at exactly the same speed the cross-shaft was provided as a mechanical tie. Adjustment of load to the two screws after erection in the field was accomplished by means of this same tie. Current readings were taken on the two motors, the flexible coupling in the tie shaft was disconnected, one motor was then turned by hand to take up or let out on one screw, and the coupling was reconnected. In this way the load on the two motors was fairly evenly balanced.

ADVANTAGES OF SCREW-LUFFING OPERATION

The investigation of the merits of screw-luffing, and the decision to manufacture screw-luffing cranes was made in part from the standpoint of safety. Wire ropes for luffing require frequent checking as to condition, and replacements are expensive because of the large quantities required. In connection with shipbuilding work, where heavy preassemblies are constantly swinging over nearly completed ships, and the failure of a luffing rope would represent a tremendous loss of time and money, perhaps involving human lives, it was desired to have a type of luffing construction which would have the same degree of dependability at all times as any part of the structure.

A further consideration was the desirability of obtaining precise control over the movement of heavy loads and sections.

Upon testing the crane, it was found to handle the load with remarkable smoothness. The rigid and smooth-running screw eliminated in large measure the bounce sometimes experienced in rope-luffing cranes resulting from sudden stopping of the load due to quick setting of the brakes or other shock. This was the case whether the load was being handled by the boom luffing or on the main hoist, with the screws merely acting as heavy links to support the boom. The screw-luffing crane was therefore found to be unsurpassed for the careful setting of heavy ship sections and other weldments, the setting of heavy machinery such as turbines, boilers, and engines, and for maneuvering large and costly sections in narrow and confined spaces where accurate control of the load was required. Direct-current control with dynamic braking was provided, giving an excellent range of speeds for these heavy loads.

Experience in the field developed that the most accurate placing of such loads was obtained by the combination of main-hoist lowering and boom-luffing. The load was maneuvered close to its final position by the usual methods, and final landing was accomplished by luffing the boom. Due to the smoothness of the screw operation, the load could be controlled at will and handled very accurately over small distances.

CONVENTIONAL DETAILS OF 75-TON SHIPYARD CRANE

Both the main and auxiliary load blocks are shown in Fig. 7. The main hook is of the double-barbed type or so-called "sister" hook, and both hooks are mounted upon antifriction thrust bearings so that the load may be easily turned independently of the block. The main-hoist reeving consists of 12 parts of $1^1/_2$-in. 6×19 wire rope and the auxiliary reeving 4 parts of 1-in. wire rope.

Previous mention has been made of the trusses in the rotating structure which support the boom, and which are shown in Fig. 8. These trusses were placed on 12-ft centers in order to keep within railway clearances and permit the shipping of large assemblies to the field. The rotating platform for instance has its main beams directly below the trusses, and the center section of the platform with these two beams was shipped as a unit. The boom width at the heel was 12 ft to correspond to the truss spacing, and again large assemblies were shipped. With this truss spacing, the hoist engines were of necessity limited in width, and a two-drum main-hoist engine was used, the two drums being powered by a common 100-hp motor. The drums were each 51 in. diam and 8 ft 6 in. long, this size being sufficient

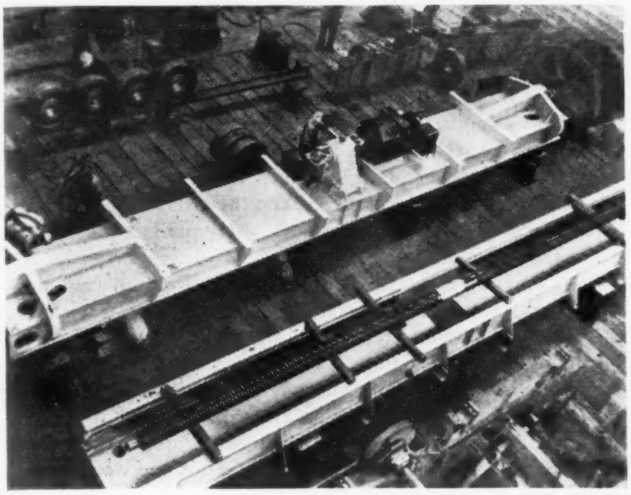


FIG. 6 SHOP-ASSEMBLY VIEW OF TYPICAL SCREWS AND FRAMES

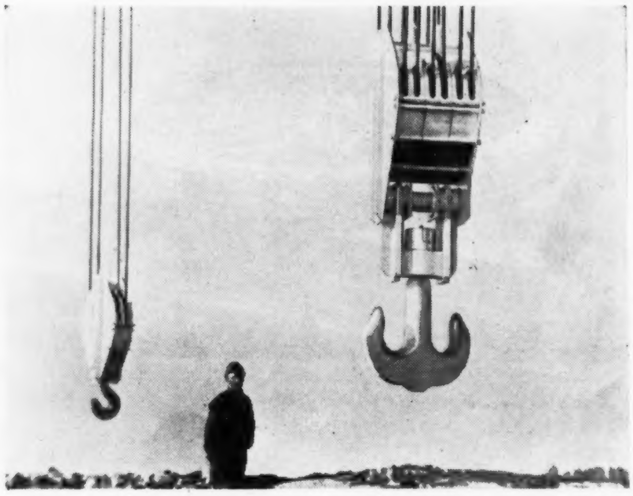


FIG. 7 MAIN AND AUXILIARY LOAD BLOCKS

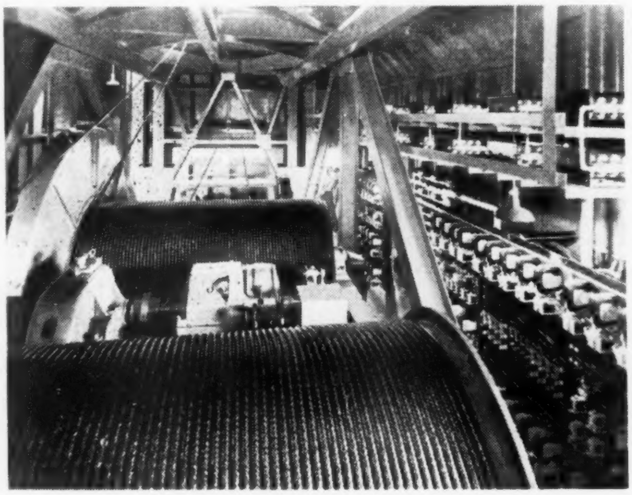


FIG. 8 VIEW INSIDE THE ROTATING STRUCTURE

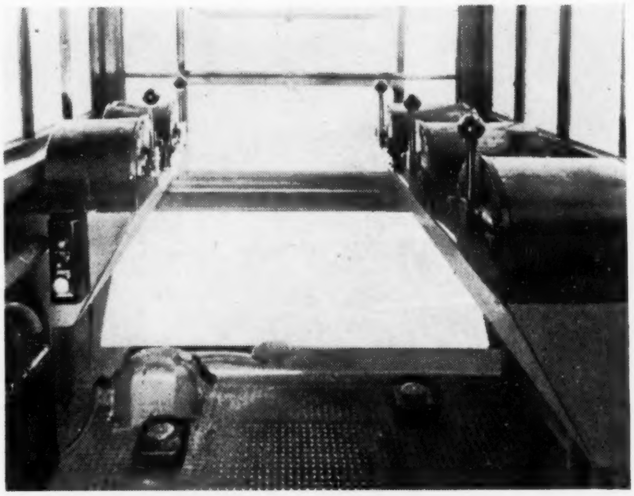


FIG. 9 OPERATOR'S CAB, SHOWING CONTROLS AND SINGLE FOOT-OPERATED BRAKE

to take all of the wire rope required in a single layer. Balanced reeving was used with the two ends of the hoist rope being attached, one to each drum. The auxiliary hoist which is not shown is independently powered by a 100-hp motor driving a single drum to which is attached the two ends of the auxiliary-hoist cable. Fig. 8 also shows the control equipment along the right side of the machinery house with resistors mounted overhead.

The swinger engine is mounted in the machinery house in a position to bring the swinger pinion directly ahead and on the center line. A single swinger is used driven by a 65-hp motor through a right-angle reducer. The output shaft of the reducer is extended to carry a bevel pinion which engages a bevel gear on the top end of the vertical swing shaft. The vertical shaft and the swinger pinion are forged integral, and the assembly is mounted in a cast-steel deadeye bearing extending through the rotating platform. The swinger pinion meshes with a cast-steel swing rack mounted on the gantry top. Control for the rotating motion is full-magnetic with reversing plugging. In addition, however, the first point of the control was made an armature shunt point providing a very slow speed which may be used when extreme care in swinging is necessary. The rotate brake is an electric-hydraulic type, and the operator can bring the load to a smooth even stop by its use.

The operator's cab with five master switches and a single brake is shown in Fig. 9. On the left are the masters for rotate and travel motions and on the right for auxiliary, main, and luffing hoists. The single brake shown foot-operated is that for the rotating motion.

While describing the swinger, no mention was made of the roller paths and roller circle. The live roller circle consists of 48 forged-steel conical rollers 12 in. average diam $\times$ 9 in. face. The rollers are made from rolled steel containing 0.67 to 0.82 carbon and 0.65 to 0.85 manganese, normalized and tempered, and are held in a structural cage with centering spider shown in Fig. 10. The Brinell readings on the rollers averaged approximately 230. In this illustration, the roller circle is shown completely assembled ready to be lowered into place on its path on the top of the gantry. The paths themselves were fabricated from slabs of steel of similar composition having an average Brinell of 250 and machined to a taper to match the conical rollers. The lower path is a complete circle 37 ft diam, while the upper path is segmental with one segment under the forward end of the rotating platform and the other segment under the rear.

FIELD ASSEMBLY OPERATIONS

Inasmuch as the entire crane is welded, some concern was felt with regard to the ability to assemble and weld the gantry and then mount thereon a roller path which had been finish-machined in the shop. In order to assure proper alignment, it was decided to machine the paths in the field after the completion of the gantry welding.

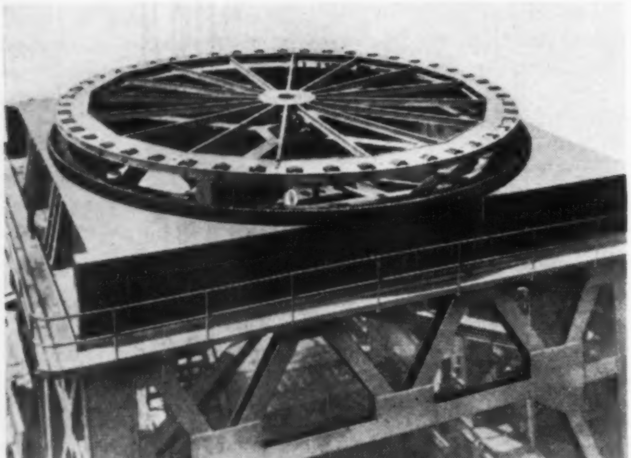


FIG. 10 ROLLER-BEARING CIRCLE, ASSEMBLED AND READY FOR INSTALLATION

FIG. 11 TURRET MILL IN PLACE ON ONE OF THE GANTRIES FINISH-MACHINING ROLLER PATH

This procedure was carried out, and Fig. 11 shows a portable turret mill in place on one of the gantries. This mill carried two cutter heads and both tools were used to shape the paths to very nearly final form. It was found that there was some tendency for the tool to tear at the slab joints, and the final finish was made by grinding. A shelter was provided over the turret mill to protect the operations from rain during bad weather and in so far as possible to avoid distortion resulting from unequal temperatures in fair weather. The segmental paths on the underside of the rotating platform were machined in the same manner by turning the rotating platform upside down and mounting the turret mill thereon. Fig. 10 also shows the external toothed swing rack in place on the gantry top.

The travel trucks are shown in Fig. 12, although the guards conceal the driving mechanism. The travel drive is of standard type consisting of a 50-hp motor crosswise of the truck with the necessary spur reductions. The motor and brake are mounted on the intermediate equalizer with the intermediate gearing centered on the pin connecting the intermediate equalizer to the driven-truck frame. The maximum static corner load was computed to be 668,000 lb or 83,500 lb per wheel, and eight 27-in-diam wheels are used, running on 171-lb crane rails. Calculations indicated sufficient tractive effort would be developed to start and travel the crane even though only one fourth of the wheels or 2 per corner were driven; the drive was built accordingly, proving satisfactory and confirming calculations.

Since only single rails were provided at the location where the crane was to operate, it was necessary to "string out" the wheels in a single line, and this required very heavy equalizers. In order to keep the pins as low as possible, the equalizers were nested. The main equalizer is built within the gantry sill and over the intermediate equalizers, and the intermediate equalizers in turn nest over the truck frames. All equalizer pins were left accessible for removal.

Fig. 13 shows a type of automatic rail clamp provided as safety equipment for material-handling bridges. Such bridges usually have a wind area large in proportion to dead weight; and automatic rail clamps are provided to prevent the bridge from blowing along the runway under heavy windstorms. For cranes of usual proportions, the ratio of wind to weight is somewhat less, and in a great many installations it is usual to rely upon the travel motor brakes during the operating day which can be supplemented by hand clamps when the crane is left for any length of time, such as during the off shift. In the first screw-luffing cranes, the location was very exposed, the cranes working on the seaboard and upon a trestle 80 ft above the ground. There was little or nothing to break the force of the wind and the prospective owner desired that automatic clamps be employed.

Application is made by means of springs actuating a toggle which spreads the arms at the top and applies a very powerful clamping force to the rail. Hardened toothed steel jaws are used to develop friction on the sides of the rail head. Release is accomplished by means of a motor-operated winch which closes the toggle by pulling the upper ends of the arms together and compresses the spring.

As has previously been mentioned the entire crane is of welded construction. Structural-grade steel is used throughout with the exception of the boom. For the boom copper-nickel-alloy steel is used in chord members with structural-grade steel for web members. Where alloy-steel sections are butted for either tension or compression chords, a mild-steel electrode is used for the root passes and a high-tensile electrode is used for subsequent passes. Where structural-steel is welded to copper-nickel steel, the mild electrode is used throughout. No difficulties were encountered in the welding and the procedures and electrodes adopted were used only after a considerable series of tests had been concluded employing a large variety of welding rods in combination with the copper-nickel steel.

TYPES OF SCREW-LUFFING CRANES

Screw-luffing cranes of lesser capacity than 75 gross tons have also been constructed. The smallest of this type crane handles

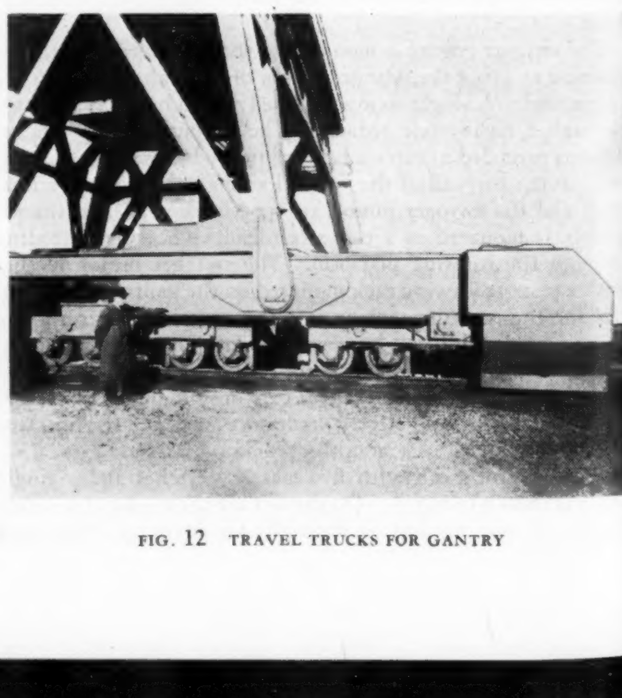


FIG. 12 TRAVEL TRUCKS FOR GANTRY

its full capacity of 20 gross tons at 62 ft 6 in. radius, although the main block will reach out to 100 ft radius with the auxiliary working out to 120 ft radius. A single screw was used, powered by a 55-hp motor, the screw being $6\frac{1}{2}$ in. root diam, 9 in. OD, and 35 ft long made in one piece. The pitch of the thread was $1\frac{3}{4}$ in., and the bronze nut was 21 in. long, giving a ratio of length-to-pitch diameter of 2.72. In this crane a triangular-shaped boom was used with a single top chord. This type of construction is relatively easily accomplished with welding but would, however, have been difficult with riveting. However, the single top chord adapts itself well to the use of the single screw.

The intermediate size of screw-luffing crane, which handles 25 gross tons at 85 ft radius with the main block reaching very close to 100 ft, is shown in Fig. 14. An extremely long boom, also triangular in shape, was provided which was necessary to suit the operating conditions required. The auxiliary block has a rating of 10 tons and can operate at reduced loads out to 160 ft. For this crane, the single screw was generally similar to one of the two screws used in the 75-ton cranes. The screw was made in halves, the pitch was $2\frac{1}{8}$ in., inside diameter $8\frac{1}{4}$ in., and outside diameter $11\frac{1}{2}$ in. The bronze nut was $29\frac{1}{2}$ in. long with a length-to-pitch diameter ratio of 2.99.

One more application of the power screw in operation will be of interest. This is the 250 gross ton traveling gantry crane used at one of the United States Navy proving grounds, Fig. 15. At this proving ground, a series of gun emplacements is built, each between a pair of rails leading off at right angles from a so-called transfer track, which is depressed below the general level of the yard. Large-size and caliber guns are brought to the proving ground on special cars. These guns are picked up by the gantry crane which then travels on a pair of access rails also at right angles to the transfer track. The crane with load travels onto a self-propelled transfer car which can travel the full length of the transfer track stopping opposite any selected gun emplacement. The crane then travels off of the transfer car and over the gun emplacement. The gun is maneuvered into its trunnions, secured in place, tested, and the necessary data taken, after which it is removed and reshipped to destination for installation.

Very precise control is required for mounting a large-caliber gun in its trunnions and the screw was here adopted for the hoisting service. Extremely low speeds were used, the hoisting rate being 12 ipm. Although 47 ft 2 in. long, this screw was made in one piece, has a root diameter of 10 in., an outside diameter of 13 in., and a pitch of 2 in. The average unit pressure between the screw and the nut is 840 lb, and the nut is 33 in. long giving again a length-to-pitch ratio of 2.87.

Whereas, in the screw-luffing cranes the screw was turned and the two nuts held against turning, in this case a single nut is turned and the screw is held stationary against rotation. The entire screw hoist is mounted on a traveling trolley which also carries a 35 gross ton and a 15 gross ton auxiliary hook. These hooks are used in conjunction with the main hook to steady the long load.

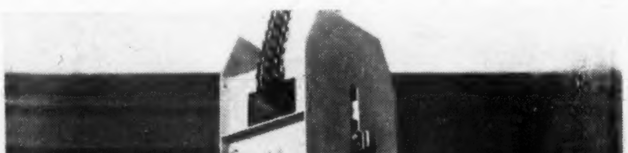


FIG. 13 TYPE OF AUTOMATIC RAIL CLAMP USED ON CRANE

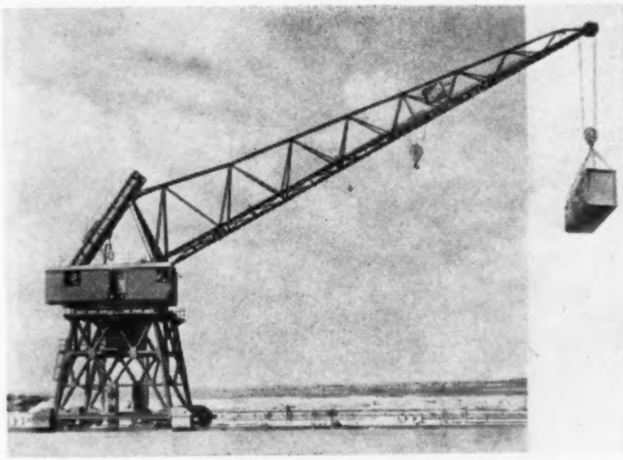


FIG. 14 SCREW-LUFFING CRANE OF 25 GROSS TON CAPACITY

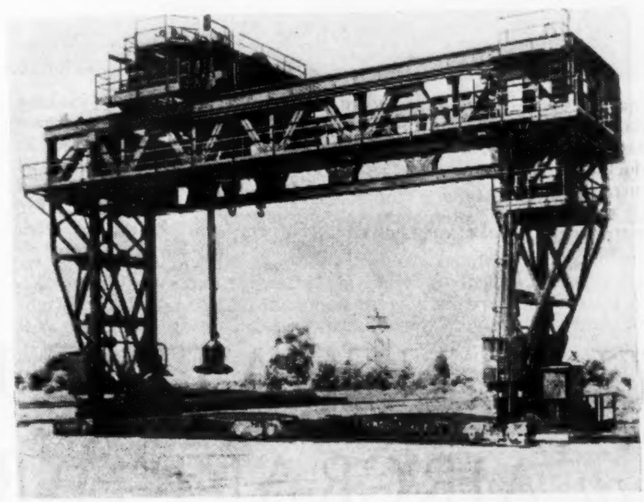
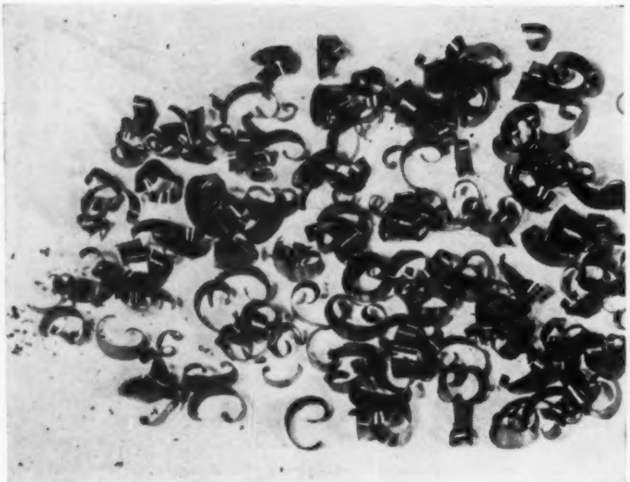


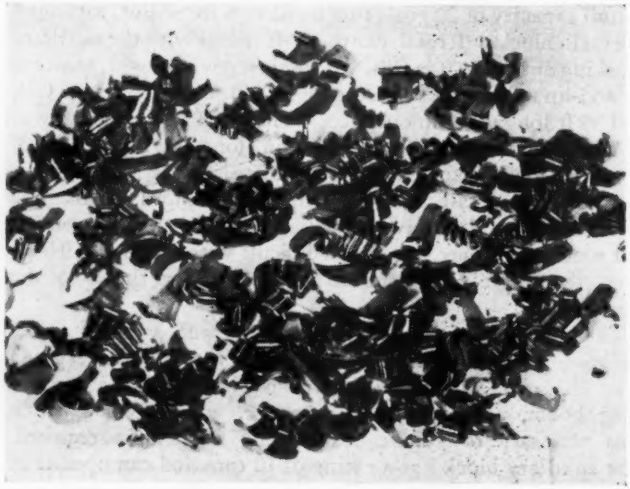
FIG. 15 U. S. NAVY TRAVELING GANTRY CRANE OF 250 GROSS TON CAPACITY FOR HANDLING ORDNANCE MATERIAL AT PROVING GROUND

ACKNOWLEDGMENT

In closing, the writer wishes to make special acknowledgment to Mr. M. M. FitzHugh, plant engineer of the Newport News Shipbuilding & Drydock Company, who as a result of his broad experience in shipbuilding foresaw the advantages of screw-luffing cranes for this field, and who contributed in an important measure to the development of this new type of crane.



Chips at 0.005 in. chip load



Chips at 0.0025 in. chip load

FACE-MILLING AT HIGH SPEED AND HEAVY LOADING

OPERATIONAL DATA

Cut	$^5/_{16}$ in. to $^3/_8$ in. deep × 3 in. wide × $5^1/_2$ in. long	Cutter speed	400 rpm, 837 sfm
Material	S.A.E. 4140 forging	Feed	25 ipm
Hardness	Approx Bhn 280	Chip load	0.005 in.
Machine	Vertical model H	Coolant	None
Cutter body	8 in. diam × 2 in. bore steel	Cutter life	73 pieces—good for 30 more
Tip material	Firthite T16	Finish	Fair
Cutter angles	Rake, 10°; helix 10°; corner $^1/_{16}$ in. × 45°; face relief 3°; peripheral relief 6°	Setup	1—Inserted-tooth face mill

Using NEGATIVE RAKE TOOLS *in* AIRCRAFT-PARTS PRODUCTION

By J. Q. HOLMES

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BECAUSE of the high stresses in the folding-wing fighter plane built by General Motors, almost all structural parts that require higher physical strength than can be obtained with aluminum alloys are made from chrome-molybdenum steel, such as 4130-4140, and chrome-nickel-moly steel such as 4340. These parts are machined in three conditions, namely, annealed, normalized, and heat-treated:

	Tensile strength, psi	Hardness, Rockwell C
The annealed runs	100000	17
The normalized runs	120000	24
The heat-treated runs	180000	40

Primarily this paper deals with the machining of these steels. The condition in which the pieces are machined is determined by the use, the limits to be held, and the warpage encountered in heat-treating.

NEGATIVE RAKE CUTTING INVESTIGATED

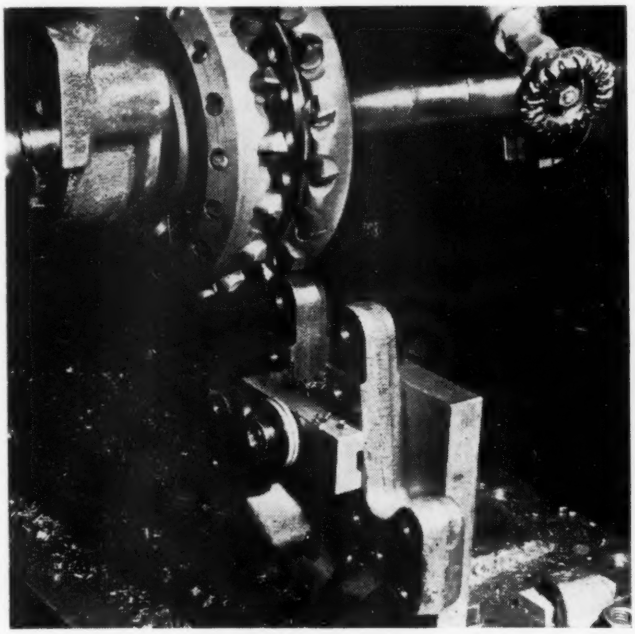
Negative rake cutting was investigated late in 1942. One of the manufacturers of tungsten-carbide told us of the performance of such tools and left us a circular describing the method. Of course, our first reaction was typical: "We knew it couldn't be done." However, one of the first things we were told in airplane work was that "one didn't have to be crazy to build planes, but it surely helped," and having learned that many new ideas would work, we decided to order a milling cutter.

Following the recommendation of the carbide manufacturer, we ordered one 6-in-diam inserted-blade face mill with negative helix and negative rake. The cutter manufacturer at once "knew" we were "screwy," and advised us they could make us such a cutter if we wanted it, but politely questioned its design and stated, if made, no such cutter would be guaranteed. We assured them we did want this cutter and would not hold them responsible for its performance.

When the cutter was delivered, the representative of the carbide-manufacturing company came in to see its test. The tool was tested on a No. 5 Milwaukee vertical mill, which was selected because it was one of our heavier machines. At his recommendation cutter speed was high but the feed per minute was only a little greater than previous cuts. Since this meant but slight increase in production, we started to increase feeds as the speed went up, holding the chip to a thickness of about 0.002 in. per tooth per revolution.

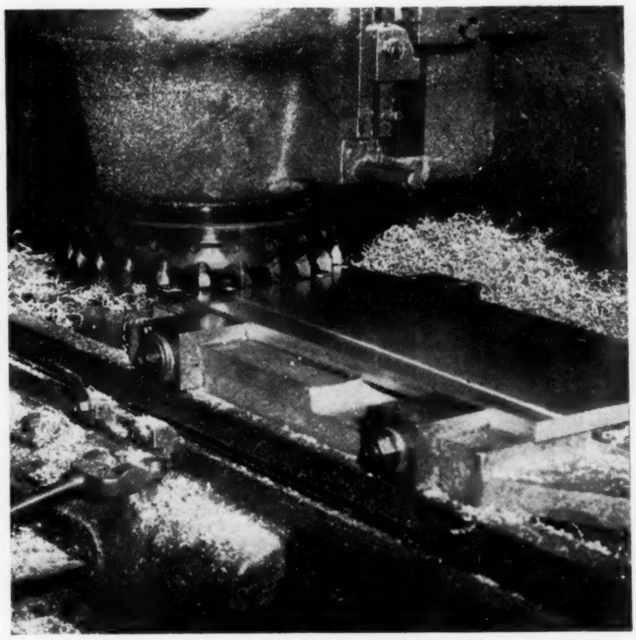
All this time the chips came off like a snow storm but red-hot; so hot that the wood-block floor was smoking. When we

Contributed by the Production Engineering Division and presented at the Semi-Annual Meeting, Pittsburgh, Pa., June 19–22, 1944, of The American Society of Mechanical Engineers.



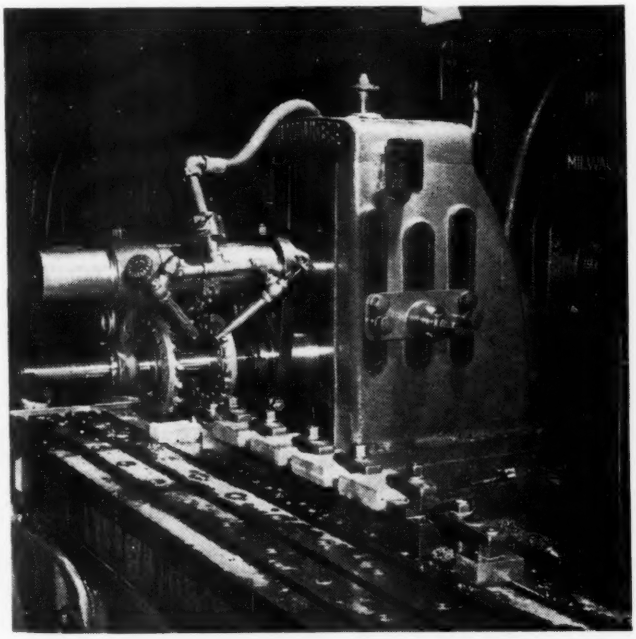
STRADDLE MILLING OPERATION ON LOCK FITTING WHICH LOCKS THE FOLDING WING IN POSITION

(It is an extremely important part on the airplane, 4140 steel, tensile strength 105,000 psi. This fixture is an example of construction too light for the job. Since this photograph was taken, the fixture has been rebuilt. The negative rake carbide-tipped cutter speed is 247 rpm, 623 sfpm, 15 ipm, .0034 cpt, depth of cut $\frac{1}{8}$, width $1\frac{1}{4}$, length $1\frac{1}{2}$, pieces per cut 180. With high-speed steel conventional, 40 rpm, 84 sfpm, feed 2 ipm, .0035 cpt, same depth, width, and length per cut, 140 pieces per grind.)



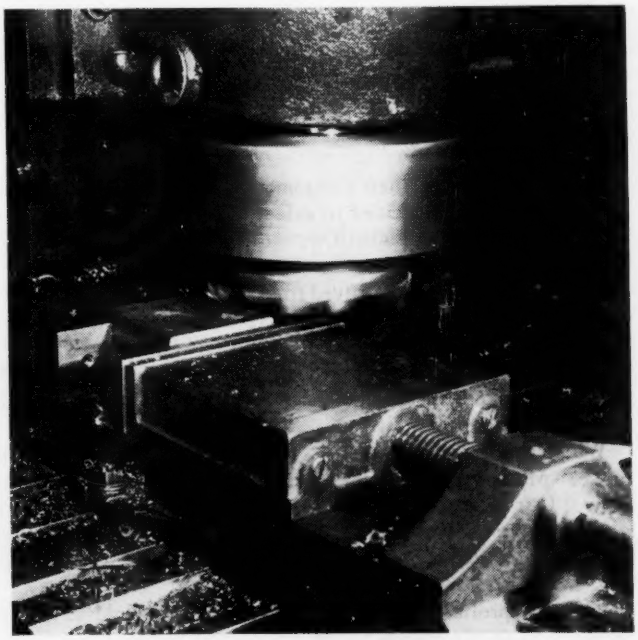
EXPERIMENTAL SETUP TO TRY NEGATIVE RAKE MILLING ON 24S-T ALUMINUM

(No trouble has been experienced with positive rake tools on this material. To see what would be acceptable, this test was run. The cutter was ground with same negative angle as has been used for steel, and produced very satisfactory results. One definite advantage of the negative rake tools on this type of work is the fact that the cutter forces the work down on to the fixture instead of tending to lift, as is done with positive rake tools. An economical advantage is that the same cutters can be used for Dural as for steel, thereby eliminating a high tool inventory.)



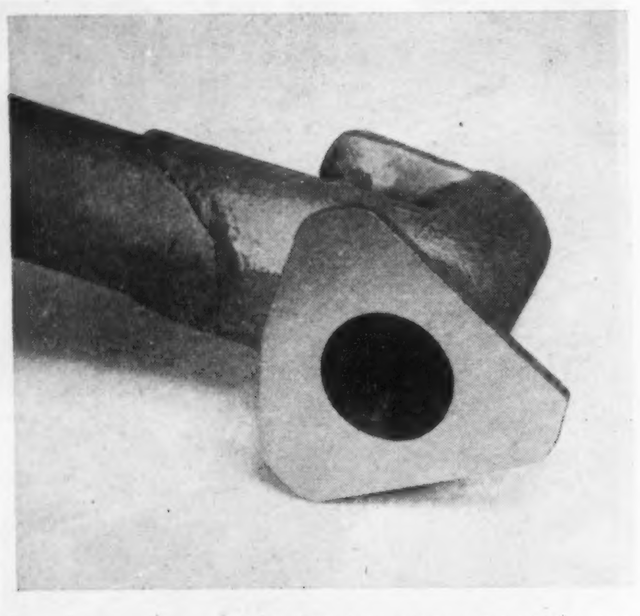
STRADDLE-MILL OPERATION ON WING REINFORCEMENT ANGLE

(With negative rake type cutters 200 rpm, 471 sfpm, feed 20 ipm, .0055 cpt, $\frac{1}{8}$ in. depth of cut, $1\frac{1}{4}$ width by $4\frac{1}{2}$ long, 144 pieces per grind. With conventional high-speed cutters, 46 rpm, 95.4 sfpm, feed 2.8 ipm, .003 cpt, depth, width, and length of cut same, 100 pieces per grind. Note that this machine is running at a very much lower speed than other operations described. This is because this machine was bought for conventional milling and 200 rpm is maximum speed obtainable with present gears. New gears have been ordered to materially increase the speed of this machine.)



WING REINFORCEMENT ANGLE BEING MACHINED ON A NO. 5 VERTICAL MILL

(4130 steel, 105,000 psi, with negative rake cutter 400 rpm, 838 sfpm, feed 25 ipm, .0045 cpt, depth of cut $\frac{1}{8}$, width of cut 4, and length $4\frac{1}{2}$. Number of pieces per grind 149. With conventional high-speed cutters, 45 rpm, 78 sfpm, 3 ipm, .004 cpt. Same depth, and width, and length of cut. Note the 138-lb flywheel on spindle. This forging is a hollow box with walls about $\frac{5}{16}$ in. thick. Even with this thin wall, excellent finish is obtained.)



EXAMPLES OF FACE-MILLING STEEL AIRCRAFT PARTS—FINISH IN ONE PASS

OPERATIONAL DATA

Cut	$^5/_{64}$ in. deep × 3 in. wide × 3 in. long
Material	S.A.E. 4140 forging HT
Hardness	Approx Bhn 350
Machine	Vertical—model H
Cutter body	6 in. diam × 2 in. bore steel
Tip material	Firthite T16
Cutter angles:	Rake 7°; helix 10°; corner $^1/_{16}$ in. × 45° face; relief 3°; peripheral relief 6°
No. teeth	10
Cutter speed	489 rpm—800 sfm
Feed	15 ipm
Chip load	0.003 in.
Coolant	None
Cutter life	158 pieces—dull
Finish	Good
Setup	1—Inserted-tooth face mill

Cut	$^7/_{16}$ in. to $^1/_2$ in. deep × $1^3/_4$ in. wide × $1^3/_4$ in. long
Material	S.A.E. 4140 forging—normalized
Hardness	Approx Bhn 280
Machine	Vertical—model K
Cutter body	6 in. diam × 2 in. bore steel
Tip material	Firthite T16
Cutter angles:	Rake 7°; helix 10°; corner $^1/_{16}$ in. × 45°; face relief 3°; peripheral relief 6°
No. teeth	10
Cutter speed	545 rpm—840 sfm
Feed	15 ipm
Chip load	.00275 in.
Coolant	None
Cutter life	112 pieces—dull
Finish	Fair
Setup	1—Inserted-tooth face mill

reached what was a then phenomenal speed of 1000 fpm and feeds of 21 ipm, we decided to call it a day. This test was run on annealed 4130 steel which we were milling every day at $1^1/_2$ ipm.

The results of this test proved to us that we really had "something"—what—we didn't know. It was decided to use this cutter and find out if this was an application of a really usable tool. Weeks of test continued. Different grinds were tried, tips were broken and replaced, proving one thing, i.e., inserted-blade cutters were necessary.

While this test work was taking place, economic problems arose. Machinery was scarce, and delivery of new machines slow. Our production schedules were increasing. The Navy wanted more—always more. Manpower was scarce too, and often when a man was trained to a point where he was producing, we would lose him to the draft.

All these problems proved to us that if parts could be run in production at the speeds found satisfactory in tests, we could produce more on our existing machines and tools and use less manpower.

Our tests had shown us another desirable improvement—finish. While we do not need the finish required in aircraft-engine work, a good machined finish is desirable. Our tests showed that with negative rake tools, finishes were much superior over those produced with positive rake. In fact, they look like ground finishes.

PUTTING THE NEW PROCESS INTO PRODUCTION

All of those findings convinced us that we should put this new method into production. It must be kept in mind that our sole reason for existence was to build more planes for the Navy and build them always better. We were not interested in the development of a new method either from a sales angle or as a problem in research or engineering. We had only one production philosophy—to get the "most of the best for the least!"

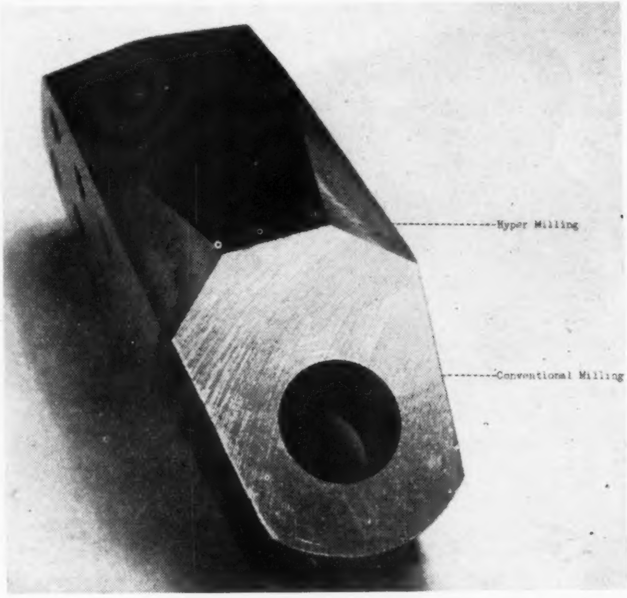
The adoption of such a program met with considerable resistance. The management thought that such high speeds were merely stunts. At first our operators were afraid. The chip problem caused the operators' resistance. The use of safety goggles was required. Speeds and feeds would be maintained while the tool engineer was present, but as soon as he left, feed would be reduced.

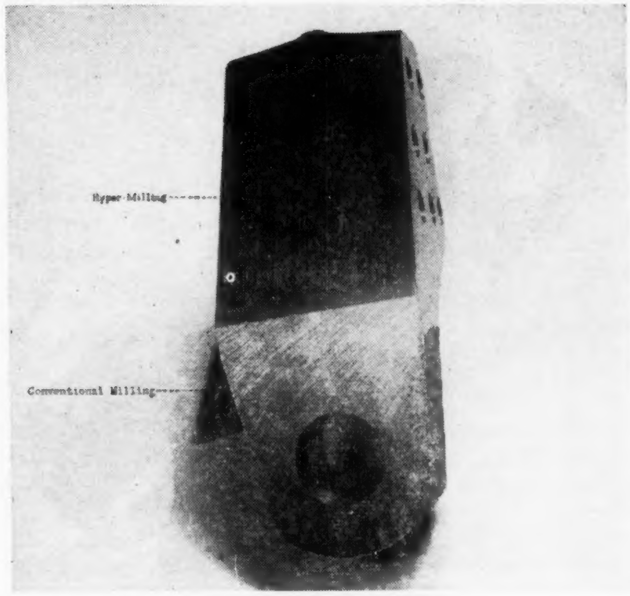
We now have about thirty jobs running with negative rake tools. These jobs are milling, turret-lathe, and precision-boring work.

MILLING OPERATIONS

The milling operations are face-milling, straddle-milling, and slotting of steel. To date no tests have been run on slab mills. The reason for this is that the cutters are quite difficult to tip with carbide. All of these milling jobs have shown remarkable increases in production. Feeds have been increased from a range of $^7/_{16}$–2 ipm to $5^1/_2$–30 ipm. The ratio of decrease in cutting time is 10–15 to 1; in fact, cutting time has been reduced to such a point that it is a small part of the total time.

Actually, to take the maximum advantage of this cutting speed, automatic loading or indexing fixtures should be built.





EXAMPLES OF FACE-MILLING STEEL AIRCRAFT PARTS—FINISH IN ONE PASS

OPERATIONAL DATA

Cut	0 to 7/16 in. at deep end × 6 in. long
Material	S.A.E. 4140 forging—normalized
Hardness	Approx Bhn 280
Machine	Vertical—model H
Cutter body	8 in. diam × 2 in. bore steel
Tip material	Firthite T16
Cutter angles:	Rake 7°; helix 10°; corner 1/16 in. × 45°; face relief 3°; peripheral relief 5°
No. teeth	14
Cutter speed	489 rpm—1075 sfm
Feed	21 ipm
Chip load	0.003 in.
Coolant	None
Cutter life	424 pieces—dull
Finish	Fine
Setup	1—Inserted-tooth face mill

Cut	5/16 in. deep × 3 in. wide × 6 in. long
Material	S.A.E. 4140 forging—normalized
Hardness	Approx Bhn 280
Machine	Vertical—model H
Cutter body	8 in. diam × 2 in. bore steel
Tip material	Firthite T16
Cutter angles:	Rake 7°; helix 10°; corner 1/16 in. × 45°; face relief 3°; peripheral relief 5°
No. teeth	14
Cutter speed	489 rpm—1075 sfm
Feed	17 1/2 ipm
Chip load	0.0025 in.
Coolant	None
Cutter life	116 pieces—dull
Finish	Good
Setup	1—Inserted-tooth face mill

We have not adopted such equipment as aircraft production does not justify such tool expense. However, the information gained will be of great value in automotive tooling.

The turret-lathe jobs are turning and facing, and often intermittent cuts. Cutting time has been reduced, since they have been running 2 to 4 times faster, with feed increases of 2 to 3 times. Speeds of 400 to 500 fpm are used with feeds of 0.009 ipm. Several parts are bored on Heald Borematics that were previously ground. These parts are all about 40 Rockwell C.

OPERATING PRECAUTIONS MUST BE TAKEN

The grinding of tungsten-carbide tools for this work must be done carefully. We have found by test that the best angles for our work are 7 deg negative helix, and 10 deg negative rake on face mills, and all our milling cutters are ground to these angles. It is imperative that these cutters be finish-ground with diamond-impregnated wheels. If silicon carbide is used, the wheel breaks down before the cutter is finished, and the teeth are of unequal length. With diamond wheels, the teeth are held to the same length within 0.0003 to 0.0005 in. After grinding, cutters are inspected to see that this tolerance has been held.

Spindles must run true and the cutters must be checked for runout after mounting on the machines. While the same problem is not encountered with lathe tools, we rough-grind with silicon-carbide wheels and finish with diamond wheels of 180 grit.

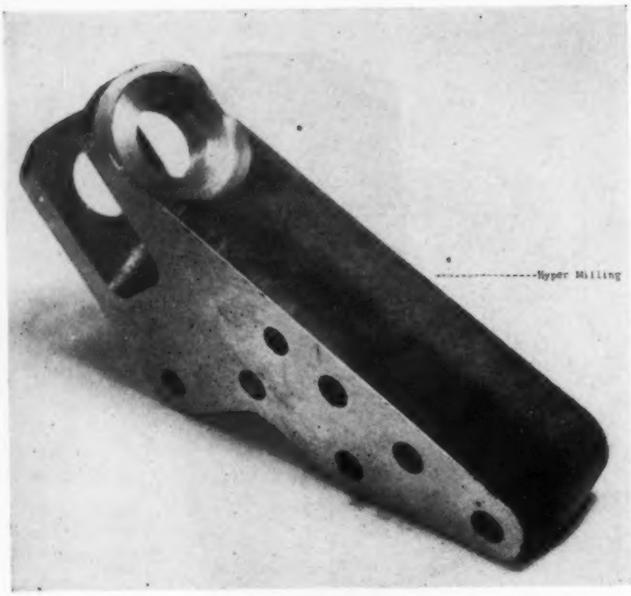
The grades of carbide play an important part in the performance of tools. We have used two grades; one for milling and turning, and another for facing when intermittent cuts are made. Several makes have been tried and, while we feel that there is a big field for tests on cutting grades, we are not doing much on this subject as we are getting excellent results from those two grades.

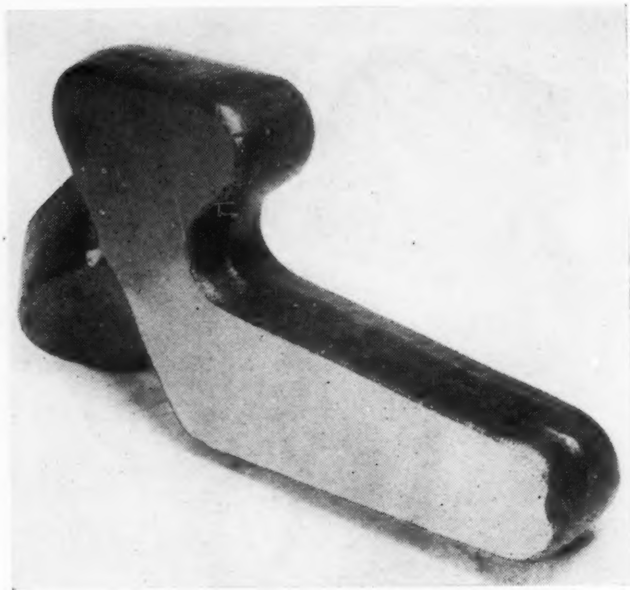
TOOTH LOAD AND NUMBER OF TEETH

Much has been written on the subject of tooth load and number of teeth. Our work has been done with the chip under 0.005 in. per tooth per revolution. At first, our speeds were higher than at present, i.e., surface speeds up to 1285 fpm with chip of 0.002 in. were used. Now we are running at speeds from 800 to 1000 fpm, with chip thickness up to 0.0045 in. on milling. Most of our mill cutters are 6 in. diam with 10 teeth, or 8 in. diam with 14 teeth. These have more teeth than many persons believe to be advisable. Again it should be emphasized that we are getting excellent results, and these are what we want.

In the examples illustrated, comparison is made between carbide-tipped milling cutters with negative rake and high-speed steel positive rake. The question may be asked: "What is the comparison between negative rake and positive rake cutters with the same grade of carbide?" We have never made that comparison because we never have had success with carbide milling cutters on steel with positive rake.

The experience of the author and his associates over a period





EXAMPLES OF FACE-MILLING STEEL AIRCRAFT PARTS—FINISH IN ONE PASS

OPERATIONAL DATA

Cut	5/16 in. deep × 2 1/4 in. wide × 6 in. long
Material	S.A.E. 4140 forging—normalized
Hardness	Approx Bhn 280
Machine	Vertical—model H
Cutter body	8 in. diam × 2 in. bore steel
Tip material	Firthite T16
Cutter angles:	Rake 10°; helix 10°; corner 1/16 in. × 45°; face relief 3°; peripheral relief 6°
No. teeth	14
Cutter speed	597 rpm—1285 sfm
Feed	17 1/2 ipm
Chip load	0.002 in.
Coolant	None
Cutter life	112 pieces—dull
Finish	Fine
Setup	1—Inserted tooth face mill

Cut	3/32 in. deep × 4 in. wide × 6 in. long
Material	S.A.E. 4140 Forging—normalized
Hardness	Approx Bhn 280
Machine	Vertical—model H
Cutter body	6 in. diam × 2 in. bore steel
Tip material	Firthite T16
Cutter angles:	Rake 7°; helix 10°; corner 1/15 in. × 45°; face relief 3°; peripheral relief 6°
No. teeth	10
Cutter speed	597 rpm—875 sfm
Feed	15 ipm
Chip load	.0025 in.
Coolant	None
Cutter life	116 pieces—slightly dull
Finish	Fine
Setup	1—Inserted tooth face mill

of years has been failure of carbide milling cutters with positive rake on steel. This condition is attributable to the fact that the tips are not strong enough to carry the load when ground with positive rake and, for such grinds, high-speed steel is more satisfactory.

Carbide, of course, has been used with positive rake in milling aluminum, and to date we do not know of a top limit of speed for this work. Recent experiments made on milling aluminum with negative rake cutters indicate that it will be possible to use the same cutters for aluminum as for steel. The advantage of this lies in better finish and reduction of cutter inventory.

We have done some test work on chip loads up to 0.008 in., but find on our mills that the spindles are light for this load. We are using Nos. 3, 4, and 5 knee-type mills in most cases. An exception is a duplex mill on a straddle-mill job. This machine has a top speed of 200 rpm, but even with this, we have increased our feed to 20 ipm over a previous speed of from 1 to 2 ipm.

We are testing flywheels on the cutter end of the spindle to see if heavier cuts can be taken. We feel that with heavier machines much more can be done than has been accomplished with our present machines.

POWER REQUIREMENTS

Many engineers have asked about power requirements. As previously stated, we are using negative rake tools for production, not research. However, we have installed meters on a No. 5 vertical 20-hp machine and have taken power readings.

A wide variety of parts were run on this machine and observations made of the power used. On the parts illustrated, the power consumption was of no consequence. Some of the readings are given in data describing photographs.

We found that a great variation exists between dull and sharp cutters. In many of the tests we found that a dull cutter pulled twice the horsepower of a sharp cutter. On one of the tests a sharp cutter required 13.4 hp while the dull cutter required 24.3. Inasmuch as the machine had a 20 horsepower motor, even this was not objectionable.

We feel that within the normal capacity of the machine, increase in power for negative rake milling is no problem. This is because with the greatly reduced cutting time, such load occurs for such a short period of time relative to the total time that the motor will carry the overload, if any, without any trouble. We have had no trouble with our motors from heating or from overload.

One interesting fact was found that, when we increased feeds, for example, on a given job from 15 inches per minute to 30 inches per minute, the increase in power consumed was negligible.

By this time negative rake tools are accepted by operators and foremen. They now are interested in seeing other jobs tooled and are receptive to the method.

There have been some cases where it has had the effect of stimulating operators to higher speeds on other operations. More jobs are being changed to negative rake tooling as fast as tools can be provided. In this plant negative rake tools are no longer in the experimental stage.

"PACKAGE-TYPE" POWER PLANTS

By H. H. VAN KENNEN and L. E. F. WAHRENBURG

MECHANICAL ENGINEERS, PETER F. LOFTUS, CONSULTING ENGINEERS, PITTSBURGH, PA.

INTRODUCTION

THE problems relating to the successful prosecution of the war, and to postwar rehabilitation, have created the urgent need for a portable-type power plant capable of producing relatively large blocks of electrical power. It is required that these plants be so designed that they can be moved rapidly and readily from one location to another to meet the critical demands for power necessitated by military, industrial, and rehabilitation exigencies. Three such types of portable plants have been developed; these types are commonly referred to as the power train, the floating power plant, and the package-type power plant.

The power train may be briefly described as consisting of the required power-generation equipment so mounted and arranged on special railroad cars that it can be moved from one point to another on a railroad system, and, upon reaching its destination, can be placed in service by making a minimum number of mechanical and electrical interconnections. The floating-type power plant consists of the required power-generation equipment mounted and arranged on a floating structure which can be towed or otherwise propelled to its point of use. The package-type power plant is made up of the necessary items of power-generation equipment in relatively large preassembled units, each in itself mechanically and electrically interconnected, which can be transported to the required destination by the medium of rail, water, or motor transportation and which, upon arrival, can be aligned on a preinstalled, simple, concrete mat or foundation, mechanically and electrically interconnected, and rapidly made ready for generating power.

The succeeding discussion will review some of the more pertinent and interesting features of the development of this third type of power plant, the package type.

REQUIREMENTS PACKAGES MUST MEET

It is advisable to define the design requirements affecting the various packages as they were initially envisioned. This initial conception, it is to be remembered, was born of the exigencies of a world emergency, and certain concessions had to be made in the attainment of the primary purposes, which were as follows:

1 The packages, whether they were crates, bundles, or skidded items of equipment, had to be of easy portability, which involves such matters as distribution of weight within the package, the general size of the package, its shape, and ready means for attaching slings properly for handling if cranes and hoists are available.

2 The grouping of the equipment contained in any one package had to be such that the package could be quickly erected in its proper relationship to other packages, and be as quickly dismantled.

3 The individual packages had to be so arranged and grouped that a minimum amount of field work would be required in the interconnection of the packages making up the complete power plant. This naturally implies a maximum of preassembly of the elements of each package. Each individual package had to be mounted on substantial skids.

4 The physical design and arrangement of the equipment within the package, and its relationship to other packages comprising the complete power plant, is to be such that the required foundation and enveloping structure can be of minimum extent and maximum simplicity. Given proper soil conditions, the ideal foundation would be a perfectly flat slab for the support of all the elements of the plant.

PHYSICAL LIMITATIONS OF PACKAGES

In order to comply with the requisite of a minimum amount of field work and a maximum amount of preassembly, it was obvious that the individual packages should be as large as possible, and, as a corollary, that there be a minimum number of such packages. However, the sizes and weights of these packages are a function of the transportation and handling facilities. Railway and highway clearances, both in this country and abroad, place severe restrictions on the width and height of the packages. Handling facilities, particularly abroad, place limitations on the weight of the packages. These physical limitations naturally limited the number of associated equipment items that could be placed in an individual package, and they also had a definite effect on the physical shape of the principal items of equipment contained in each package.

It is well, at this point, to refer to Fig. 1, which portrays the railroad-clearance diagram. It can be seen that, in general, the foreign clearances were the limiting factors. The contour of the clearance lines of the railways is such that the maximum clearance exists above the center of the railroad car. As a conse-

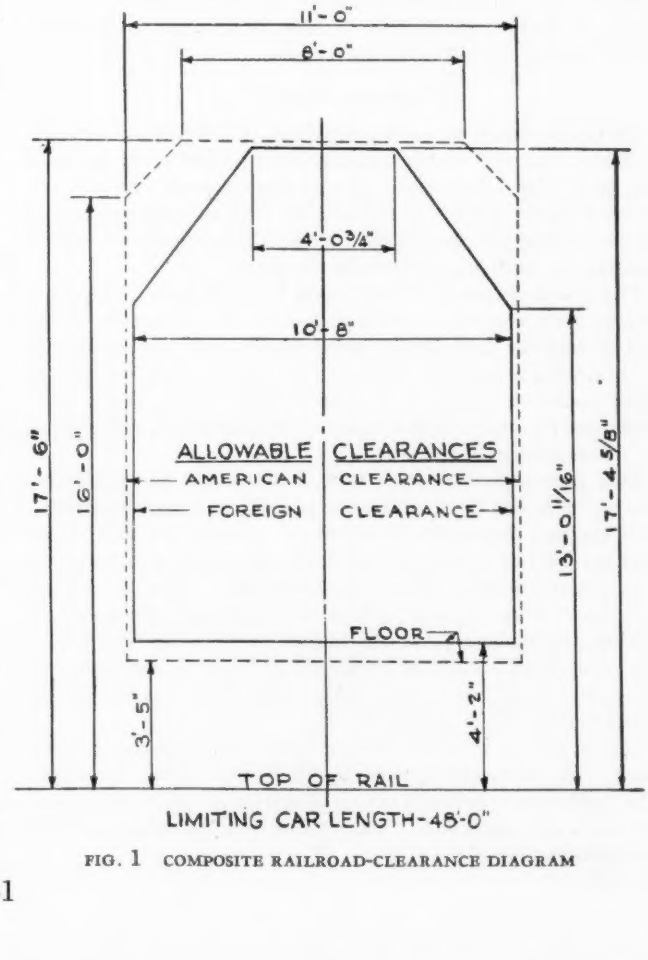


FIG. 1 COMPOSITE RAILROAD-CLEARANCE DIAGRAM

Contributed by the Power Division and presented at the Semi-Annual Meeting, Pittsburgh, Pa., June 19–22, 1944, of The American Society of Mechanical Engineers.

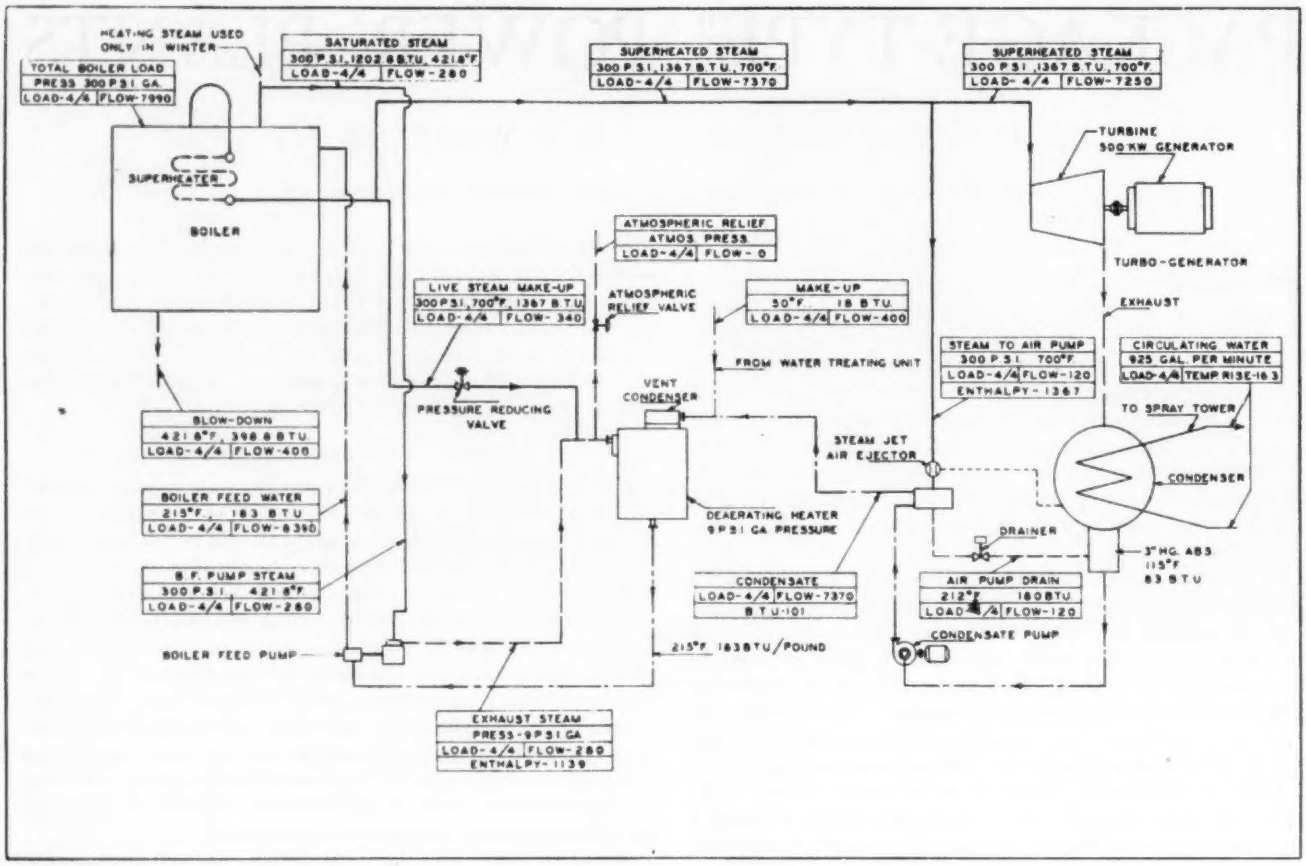


FIG. 2 HEAT-BALANCE DIAGRAM

quence, a boiler of the longitudinal-drum type had certain inherent advantages over a boiler of the cross-drum type. However, it does not necessarily follow that the cross-drum-type boiler, by certain adaptations of basic design, cannot be made to fall within the limiting restrictions.

THERMODYNAMICS

Up to this point we have generalized in connection with the problems relevant to the package-type power plant without any particular reference to its component parts, beyond the mention that the plant is intended to deliver electrical energy for use outside the plant itself. In the following discussion our remarks are limited to steam-electric plants.

The plants discussed herein must be capable of utilizing a fuel of a type which is most abundant in and native to the specific locality designated. Furthermore, we discuss specifically a 500-kw-capacity package-type power plant. Plants of this capacity seemingly are in great demand because of the war's needs, and they have been developed, manufactured, and shipped to the far corners of the world.

In a power plant of this type, using steam for the prime mover, there has been, up to the present, at least, no particularly unusual thermal cycle involved. In fact, the limitations imposed by the packaging principle necessitated simplifying the cycle to the point where the minimum number of items of equipment were required. This simplification forced certain sacrifices in efficiency, and the thermal cycle became essentially one of a direct circuit of boiler to turbine, to condenser, to feedwater heater, to boiler, and contained none of the refinements of stage-heating and the like.

Fig. 2 shows the heat-balance and flow diagram of this plant. The plant heat rate of 31,000 Btu per kwhr is comparable with that to be found in similar stationary plants of equivalent sizes and capacities. The station net kilowatt capacity is approximately 476.

Disregarding for the moment the question of availability of a satisfactory and continuous boiler-water supply, it would be possible to simplify the cycle further by exhausting the prime mover to atmosphere. However, as the size limitations of the packages imposed themselves most restrictively upon the steam-generating unit, it was generally advisable to add to the plant those items of equipment, such as condensers, which would assist materially in reducing the steam demand, and therefore the unit's physical size, even though doing so might increase the possible total number of packages required to make up the complete power plant.

It was also necessary, due to lack of previous information with respect to the point of ultimate use of the equipment, to accept a rather broad basis of design and to provide a cycle and arrangement of equipment which would operate with reasonable efficiencies over a wide range of climatic conditions and with varied conditions of fuel and water supply. The niceties of thermal design that may be incorporated in the ordinary stationary plant, located on a fixed site with known basic conditions, cannot be applied conveniently to the type of plant under consideration.

SPECIFIC APPLICATION

General Considerations. The foregoing general statements cover some of the basic limitations of plants of this type. It is now in order to review some of the more pertinent and specific details involved in the design of a definite project involving a large number of package-type power plants being delivered abroad. Such a plant is shown in Fig. 3.

The emergency of this project required the consumption of a minimum amount of time between its inception and the delivery of the completed plants. This forced a recognition of the then current situation with respect to critical materials, and the necessity of accepting equipment designs that had already been developed and standardized and to which therefore only

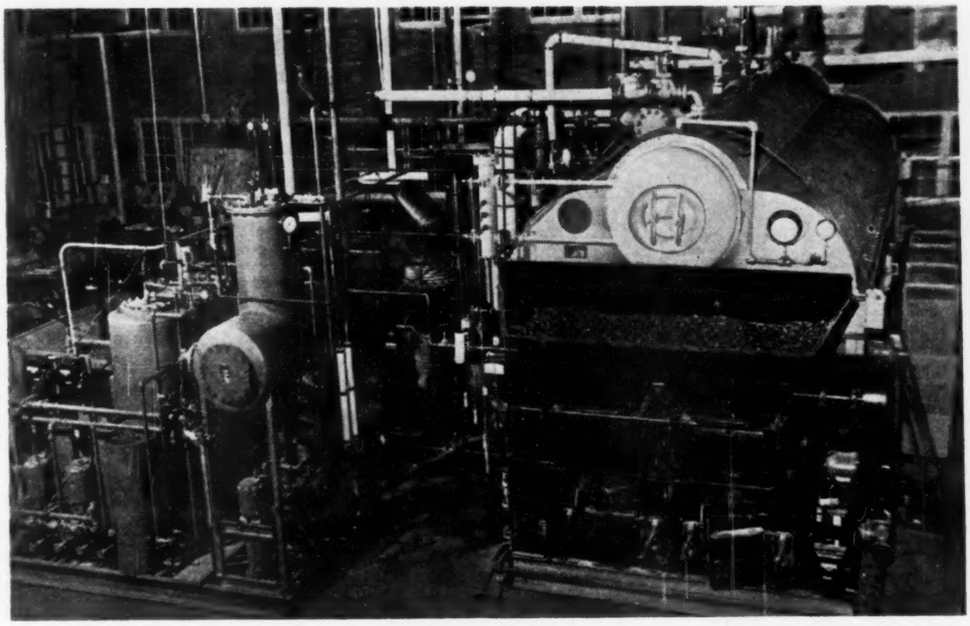


FIG. 3 PACKAGE POWER PLANT UNDER TEST

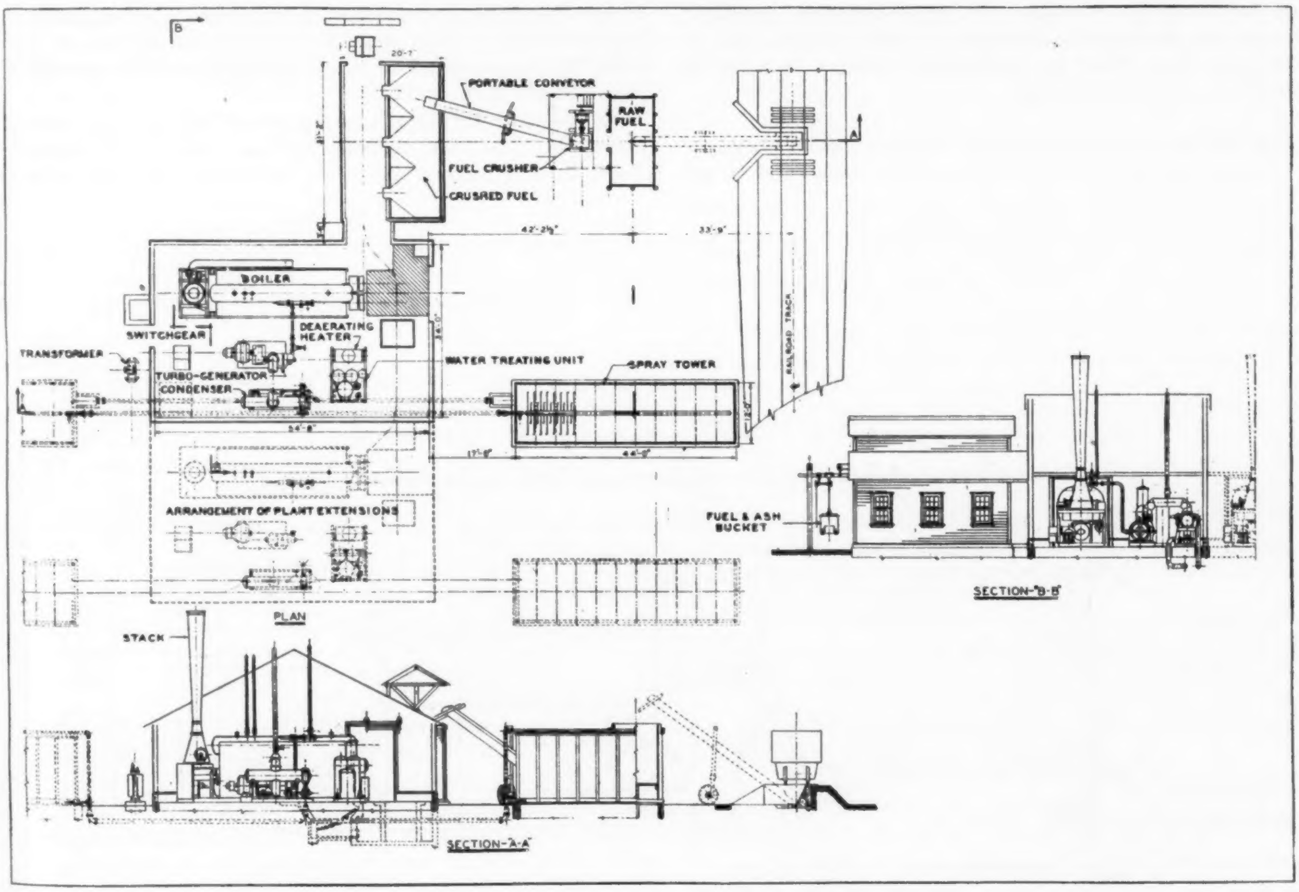


FIG. 4 GENERAL ARRANGEMENT OF THE PACKAGE POWER PLANT

minor adaptations could be effected. Because of full shop schedules, many manufacturers who could usually have furnished satisfactory equipment were not in a position to offer any of their equipment.

Wartime restrictions dictated keeping the use of cast steel and all alloy steels to a minimum. If cast iron throughout was adhered to, the top limit of steam pressure and temperature was obviously 250 psi and 450 F. However, one of the large manufacturers of small turbines has standardized on a design of turbine using steam at 300 psi pressure and 700 F temperature and requiring a minimum of steel. A study of the economics of the two steam characteristics indicated that a savings of approximately 16 per cent in efficiency could be effected by utilizing the higher steam pressure and temperature conditions. The turbine referred to herein uses cast steel only in the strainer body, throttle and governor valve bodies, and the nozzle

block. The choice of this pressure-temperature condition also permitted the use of Series 30 piping rather than Series 60 piping.

Electrical energy was specified to be delivered at 400 v, 3 phase, 50 cycles, 0.8 power factor, and the capacity of the generator was established at 500 kw.

The entire plant was divided into eight functional units, each with its auxiliary equipment. These units consisted of steam generator, turbogenerator, switchgear, condenser, spray tower, feedwater unit, interconnecting piping and wiring, and fuel handling.

Fig. 4 shows the general plan and assembly of the 500-kw package-type, power plant. It clearly shows eight functional units. The floor area is 34 ft by 55 ft. Because of the compact nature of these plants, they may be located in areas available in industrial establishments, public buildings with large foyers, railroad-station lobbies, or in temporary wooden or more permanent brick structures especially built for the purpose.

It was stipulated that each of these units, together with all its related auxiliary equipment and piping, should be prefabricated and shop-assembled to the maximum extent permissible under the specified clearance and weight limitations, and that the individual assemblies should be crated in accordance with the government's requirements for overland and overseas transportation. Final determinations resulted in a total of 24 packages for the entire power plant; fifteen for the steam generator, three for the fuel-handling equipment (which includes the unusual item of a crusher for each plant), and one each for the remaining six functional units.

Steam Generator. The specification requirements for the steam-generating unit were particularly severe, inasmuch as it was necessary to make provisions for burning three fuels, i.e., wood, peat, and coal of exceedingly low heating value and other adverse characteristics. The boiler, further, was required to deliver 12,000 lb of steam per hr continuously, a quantity some 3500 lb per hr in excess of the turbine and auxiliary requirements, because it was considered desirable to provide for a quantity of process and heating steam. Finally, as it was assumed that the plant might be located in an isolated area with no outside power available, the design of the complete station had to be such that it would contain all of the elements necessary to bring it into the line without benefit of outside power.

Fig. 5 shows a cross section of the steam-generating unit. Basically the unit selected consists of a boiler of the longitudinal-drum type, with superheater in the first pass, no air preheater or economizer, a water-cooled furnace, equipped with a spreader-type stoker for burning coal and peat, and a refractory furnace built under the water-cooled furnace, equipped with sloping stationary bar grates for firing wood.

The appurtenances consist of a forced-draft fan to supply air under the grate for peat and coal combustion, and overfire air for wood burning; an induced-draft fan with Venturi-type stack; cinder-recovery equipment; and the usual complement of boiler accessories including furnace draft regulator, feedwater-level-control assembly, all piping up to and including the last blowoff valve, and the superheater-outlet header. Both the induced- and forced-draft fans are motor-driven; however, in order to provide for bringing the unit into the line and furnishing enough steam to start the turbogenerator and other plant auxiliaries, a steam-aspirating-jet ring is provided in the throat of the stack.

The basic operation of starting up the package-type power plant consists of firing the boiler by hand, starting with natural draft, then providing additional draft when sufficient steam

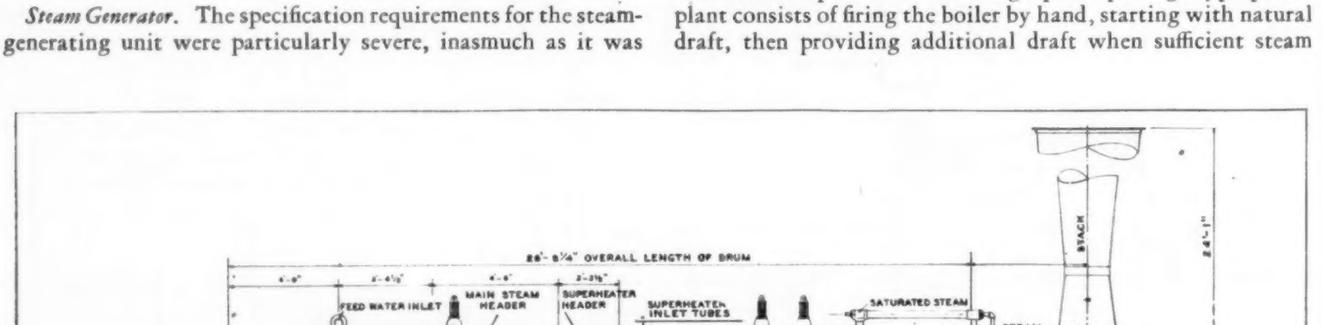


FIG. 5 CROSS SECTION, STEAM-GENERATING UNIT

pressure is available to furnish steam for the steam ring in the stack. When 50 psi pressure is available, the boiler feed pump will operate. At a higher pressure the turbogenerator is started exhausting to the atmosphere and generates sufficient electrical energy to operate the fans and stoker electric drives. The steam-generating unit will generate approximately 4700 lb of steam per hr at 300 psi pressure without fans. This quantity of steam will permit about 100 kw generation, operating with atmospheric exhaust.

The necessity of providing for wood-burning complicated the general arrangement to a material degree and accounts for several of the fifteen packages required to ship this unit. If wood-firing were eliminated, the design is such that the complete unit could be placed on a flat concrete slab.

The wood-burning provisions are rather unique. It was contemplated that there will be green logs burned, cut from adjoining forests, if necessary, having a length of 30 in. and a diameter not exceeding 8 in. These logs will be manually introduced into the furnace through an air-locked magazine. Natural draft will furnish the primary air and the forced-draft fan will furnish the overfire air.

The two major packages of the assembly consist of (*a*) the boiler, superheater, and furnace proper and, (*b*) a rear assembly upon which are mounted the fans, a section of duct work with dampers, and the lower portion of the stack. This latter package is arranged for easy positioning and attaching directly behind the boiler. In order to meet weight limitations, it was necessary to package the stoker fronts with the operating mechanism, and to package the grates separately. To meet physical clearance restrictions, the upper portion of the Venturi stack and the section of forced-draft air duct along the side of the boiler had to be packaged separately. For the purpose of protection against damage in shipment, a considerable portion of the accessories and small piping about the unit, such as water gage columns and safety valves, were packaged separately, but in all cases the piping removed was prefabricated and subassembled in units to permit easy and rapid installation in the field.

Turbogenerator. No particular difficulties were encountered with respect to the packaging of the turbogenerator of 500 kw capacity. A top exhausting arrangement is used, in keeping with the desire to simplify foundation structures, and for the same reason the turbine oil reservoir and piping are held above the floor line. A continuous structural-steel bedplate is provided, of sufficient strength and of a design to permit this bedplate to serve also as a skid for moving the unit.

As it is necessary to operate the unit noncondensing for a short time during the starting-up period, the materials used in the construction are such as will safely permit the corresponding temperatures of the steam at the exhaust of the machine.

Switchgear. The control panel is arranged in one unit, and is of the dead-front totally enclosed steel type. A substantial steel base is provided to facilitate moving it without distortion of the panel and enclosure. More than the usual number of outgoing feeder circuits are provided, as the distribution from this board is naturally indeterminate. The usual protective devices are provided, together with the necessary indicating voltmeters, ammeters, and the like, and a watthour demand meter is provided to measure the generator output. Each outgoing feeder has a current transformer in one leg of the circuit. The secondaries pass through a selector switch to an ammeter, permitting the determination of the current flow at any desired time. These arrangements for metering the outgoing feeders were dictated by the then critical situation with respect to electrical metering devices.

A basic premise was that the load center would be close to the plant and distribution is therefore at 400 v; however, in order to provide for some cases where this might not be entirely true, some of the plants are provided with a 300-kva, 3-phase, step-up transformer to 6600 v.

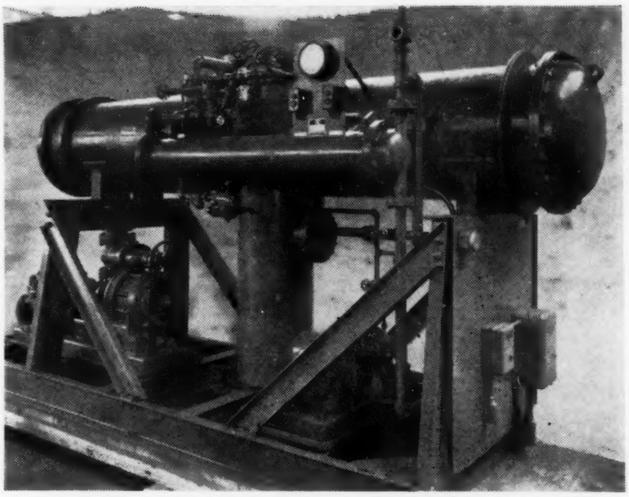


FIG. 6 ASSEMBLED CONDENSER PACKAGE

Mounted within the cubicle of the switchgear unit is a 1000-w gasoline-engine-driven automatically controlled emergency lighting unit. The voltage of the lighting circuit is 230 v, and the normal lighting energy is brought direct from the generator winding from which all six terminals have been brought out. Thus the necessity of any lighting transformer is eliminated. There may be some question, in this day of reliable flashlights and good lanterns, as to whether an emergency lighting set for a plant of this small capacity is necessary; however, in war zones not even these may always be immediately available, and so an emergency lighting unit was provided. Upon failure of the main power unit, this emergency lighting unit will automatically respond within 15 sec.

Condensing Unit. The condenser assembly, which consists of one package, was designed for mounting on a flat slab located at the same elevation as the turbogenerator. This unit is shown in Fig. 6. A substantial, structural-steel base is provided, and the condenser (of a two-pass surface type) is elevated above this base. Mounted on the base are motor-driven condensate and circulating water pumps. The aftercondenser and two single-stage air ejectors are compactly arranged at the side of the assembly. All of the interconnecting piping between the elements of the unit is installed in operating position.

Spray Tower. Because of the varied and uncertain nature of the quantities, qualities, and temperatures of available condenser circulating water, it was determined that provision should be made for cooling the circulating water. The availability of a river or similar source of supply was not depended upon.

Employment of a spray pond would place a large burden of work at the ultimate site in preparing an adequate and satisfactorily watertight reservoir, while the use of a cooling tower would involve a considerable quantity of intricate woodwork assembly. A compromise was reached by selecting a spray tower which simplified the woodwork assembly and also reduced the foundation and concrete reservoir work to a minimum. As any and all woodwork was to be supplied in the field, the spray-tower equipment consists of the piping, spray nozzles, and the hardware necessary to assemble the woodwork. All of this material was conveniently combined in one case.

Feedwater Assembly. The feedwater assembly consists of all the equipment necessary to the clarification, softening, treating, and heating of the boiler feedwater, as well as the feed

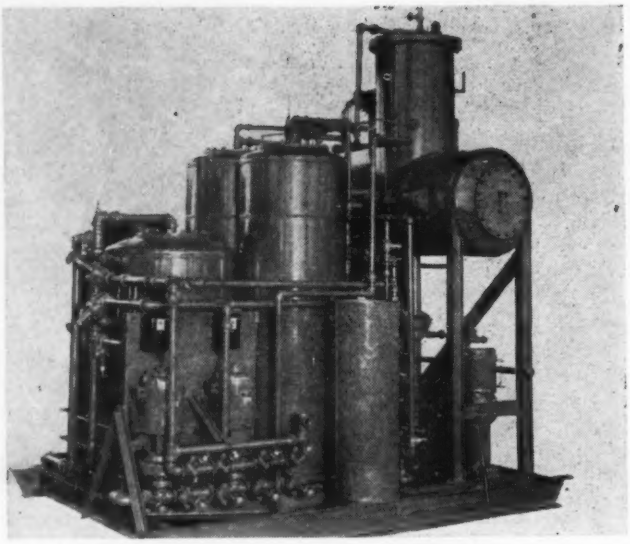


FIG. 7 FEEDWATER UNIT ASSEMBLED

pumps, and the required interconnecting piping. The compactness of the arrangement is such that the complete assembly can be included in one package. This assembly is shown in Fig. 7, and the flow is shown diagrammatically in Fig. 8.

The essential elements of this assembly consist of the following items:

1 A pressure filter of approximately 14 gpm capacity.
2 Two Zeolite softeners, each of 9 gpm capacity.
3 Two duplicate backwash pumps, so arranged and interconnected that one can be utilized for delivering water to the filter in the event the raw-water supply is of insufficient pressure, while the second can be utilized for backwashing both filters and softeners.
4 A spray-type deaerating feedwater heater of 12,000 lb per hr capacity, having in conjunction with it a 10-min storage tank.
5 Two 40-gpm noncylinder-lubricated steam-driven reciprocating boiler feed pumps.

Because of the possibility of low pressure in the raw-water supply, it is required that there be constructed at the site, and incorporated in the foundation slab, two concrete reservoirs of medium capacity; one to store a supply of raw water, and the other to accumulate a supply of clarified hard water for backwash purposes.

Piping and Wiring. Inasmuch as each individual group of assembled equipment carried with it all the preassembled, interconnecting piping and wiring between motors and starters, there remained only the necessity of providing the necessary piping and wiring to interconnect these assemblies. As each assembly was made up of associated apparatus, the items involved in the interconnection of the assemblies was held to a minimum. It was possible, therefore, within the limits of shipping clearances, to crate all of the necessary piping, valves, fittings, pipe insulation, conduit, and wiring in one case of about 6 ft in cross section and 20 ft long which is shown in Fig. 9.

All piping of 2 in. nominal diam and over was entirely prefabricated and shop-assembled in the largest pieces consistent with shipping clearances. The smaller sizes of piping were shipped in random lengths, with the necessary loose valves, fittings, and so forth, all marked for easy identification for fabrication and assembly in the field. High-pressure piping systems were of welded construction. For the most part, the low-pressure steam and water systems were of screwed construction.

The main generator leads to the switchgear were shipped in one length, to be cut in the field. The smaller wiring for auxiliary power circuits wa sshipped in coils of sufficient lengths to be cut in the field, as required. The conduit (electric metallic tubing in this case) was furnished in trade lengths. Necessary connectors, couplings, fittings, ground rods with connectors, and bare ground wire were included. Miscellaneous cable supports, bushings, etc., were furnished for field installation. All items were appropriately marked for ready assembly.

Fuel Handling. Given a good quality of coal, it would not have been necessary to furnish any facilities for fuel and ash handling beyond wheelbarrows and shovels. The fact, however, that exceptionally low-grade coal (5900 Btu per lb) and peat (5000 Btu per lb), as well as wood (5000 Btu per lb), is involved, indicated that large volumes of fuel will have to be moved. Consequently, conveying equipment of the tramway-bucket type was furnished, together with a portable conveyer for unloading coal to a raw-coal bin. With each of these plants, a coal and peat crusher was provided, as it is not always possible to obtain prepared sizes of coal and peat at the various plant sites. The portable conveyer also will be used to deliver coal from the crusher discharge to the prepared-peat and prepared-coal bin. Cordwood will be moved into position for hand-firing by substituting slings for the bucket of the tramway system. All coal bins are temporary wooden structures.

TEST PLANT

This package-type power plant has been so designed as to permit its complete assembly, from the arrival of the equipment on flat cars to actual power generation, within a period of 36 hr. This time element is of extreme importance, since in many instances these plants will move with armies. To demonstrate the possibility of attainment of this time schedule, as well as to

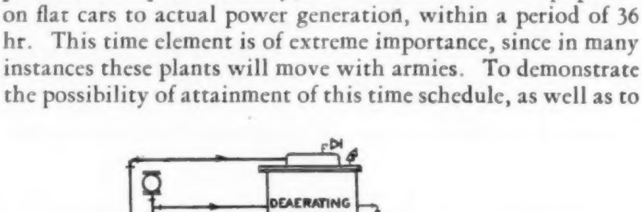


FIG. 8 FEEDWATER UNIT FLOW DIAGRAM

TABLE 1 TEST RESULTS OF 500-KW PACKAGE-TYPE POWER PLANT, APRIL 1, 1944

Steam pressure, psi	292
Steam temperature, deg F	658
Turbine exhaust pressure, in. Hg abs	2.83
Steam generator output, lb per hr	8232
Generator output, kw	499.4
Auxiliary power requirements, kw	23.8
Net station power output, kw	475.6
Steam-generator efficiency, per cent	72.1
Turbogenerator steam rate, lb per kwhr	13.8
Net plant heat rate, Btu per kwhr	27500

demonstrate the adequacy of the plant's performance, the plant herein described was actually set up and operated, and met all anticipated requirements.

Each plant was furnished with a complete manual, including instructions and drawings, for construction, operation, and maintenance. Each individual item of the assembly was appropriately marked with an identification which relates to the manual. Performance data of this plant are given in Table 1.

FUTURE APPLICATIONS

Up to the present time, engineering thought has been devoted to the design of a package-type power plant wherein the features of portability, adaptability to a wide range of conditions, and rapidity of erection and disassembly have been the prime considerations, in order to meet emergency conditions. Whether the basic idea may be refined and modified to the point where the package-type power plant could, in times of peace and more leisurely economy, compete with plants of the stationary type, each one of which is designed to meet specific conditions, is a question for examination and debate at a later date.

The electrical generating capacities of these plants can be increased readily to 1250 kw within the limitations of the present steam-generator unit, water-treating units, and their accessories and appurtenances. Much of the initial development for such increased capacities already has been accomplished.

In reviewing the description of the 500-kw package-type plants, it should be recognized that these were designed to meet specific requirements that involved the use of wood and peat, as well as a very low-grade coal, as fuels, and also that provision was made for process steam. On the reasonable assumption that no process steam would be required, that the use of wood and peat would be eliminated, and that a prepared coal of at least 8000 Btu per lb heating value would be available, the modification and, to a large extent, the simplification of the equipment would be as follows:

1 The steam-generating unit as now designed and constructed would produce the steam required by any turbogenerator up to 1250 kw capacity.

2 The turbogenerator and the condenser would, of course, be increased to the desired capacities, but the form and elements entering into the individual packages would remain as designed.

3 The form and general arrangement of the switchgear would remain the same and would be modified only to the extent necessary to accommodate it to the prescribed voltage and loads.

4 The water-treating and heating unit is of sufficient capacity to serve a plant generating up to 1250 kw, and would require no change.

5 For plants of capacities in excess of 500 kw, the substitution of an induced-draft cooling tower, completely assembled and designed to meet all transit restrictions, rather than a spray tower, is indicated because of the larger amount of cooling water necessary.

6 With the availability of prepared coal of higher heating value, and the elimination of peat and wood as fuel, the coal-handling facilities can be materially simplified, and might be eliminated entirely.

On the basis of standardization of several plants of varying capacities, it is an established fact that an exceedingly low unit cost per kilowatt of installed capacity can be attained.

It is entirely within the realm of imagination that this idea of package-type power plants may be further developed along the lines of a mail-order business.

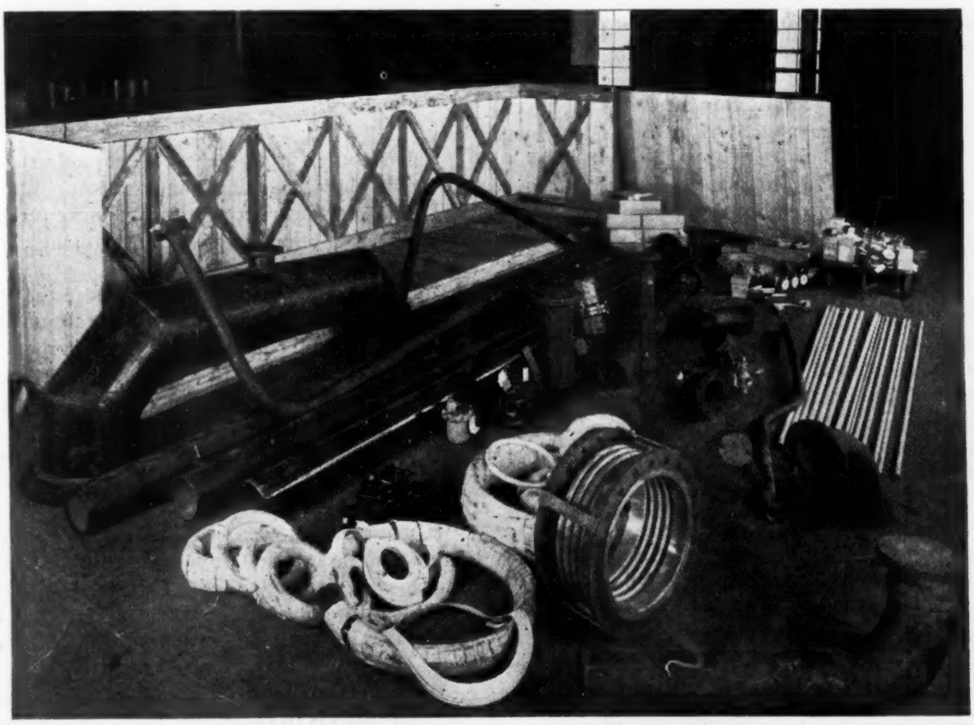


FIG. 9 CRATE CONTAINING ALL PIPING AND WIRING

Insuring Effectiveness in ENGINEERING TRAINING

By R. L. MAW

ENGINEERING TRAINING CO-ORDINATOR, CONSOLIDATED VULTEE AIRCRAFT CORP., SAN DIEGO, CALIF.

IN reviewing events of the past two years, it soon becomes apparent that industry's efforts to overcome a disastrous shortage of trained manpower were made possible largely through training. Fortunately, the seriousness of this shortage was recognized during its early stages. Corrective action was taken, with the result that previously unheard of production schedules were not only achieved but were also maintained. Of the many minor miracles that attended this upheaval perhaps the most outstanding is the now commonplace use of women in positions requiring technical knowledge. The initial prophecies that women must be used widely in place of men were greeted with much skepticism which with time changed to reluctant tolerance, and later to approbation.

Among the first of the firms in the aircraft industry to recognize the necessity for training was Consolidated Vultee Aircraft Corporation. As early as January, 1942, it was operating full-time classes in engineering drafting for the purpose of adapting men and women without technical schooling or experience to positions in the engineering department.

That this program has been effective is attested to by the fact that, of the 1137 trainees accepted for prefactory preparation in 1943, more than 65 per cent are still on the pay roll, and that approximately 70 per cent are women.

Now that initial manpower problems have been solved, the aircraft industry is suddenly faced with the crippling loss of all male employees under 26 years of age. Statistics released recently by the Aeronautical Chamber of Commerce lend stark realism to the gravity of this situation. They show that, in sixteen of the major aircraft plants having a total of approximately sixty-four-hundred trained engineers with one to six years of experience, 27.4 per cent (excluding 4 F's) are under twenty six and subject to immediate induction; 42.7 per cent are under twenty-eight years of age; and those under thirty years bring the total (not including 4 F's) to 55.5 per cent.

These losses coupled with those due to normal turnover would indicate that the training emphasis must be shifted from the prefactory preparation of beginners to the upgrading of those now having a year or more experience in the plant. Training of beginners need be continued only to the extent of providing replacements.

This need for upgrading was also recognized at an early date. As early as the summer of 1942, the Consolidated Vultee engineering department inaugurated a limited program of upgrade training designed to give selected individuals an additional boost on the road to advancement. Since then this effort has increased steadily, with the result that a number of students who two years ago were beginners now handle engineering positions requiring appreciable design responsibility.

In the more advanced upgrade training, it is even more important that maximum efficiency be achieved. Here the problem is not to teach set drafting-room practices and skill in producing detail drawings from sketches and layouts, but rather to teach the process of analyzing a job and applying the necessary principles to effect a sound solution. There are very few set procedures to act as a guide in such work; success depending upon development of ability to visualize and compromise. Conditions vary infinitely with each job, and the number of illustrations that can be used in class are limited; the student must be made to realize the full implication of this precept.

In each type of training, the minimum effort required for reasonable effectiveness varies, but the basic elements of effectiveness remain constant. Neglect of any one of these elements will result in varying degrees of failure.

INSTRUCTOR SELECTION

Probably the most important single factor in providing true effectiveness in any training program lies in the selection of instructors. If competent and willing to make the necessary effort, they will assure the successful completion of their classes. In wartime emergency training it is especially necessary that the instructor be not only thoroughly grounded in the fundamentals of his subject, but he must be experienced in the practical application of these fundamentals. In addition he must be able to impart that knowledge to others in a clear understandable manner. Other essential qualifications include ability to analyze student reaction, ability to organize the work, and prepare effective methods of presentation.

If full efficiency in training is to be realized, every possible effort must be made to develop these abilities yet further. The only qualified agency available for this purpose is the universities charged with the responsibilities of operating college-level war-training programs. Though university representatives have to an appreciable extent minimized this problem already, a more active supervision of instructors would be certain to result in worth-while improvements.

PARTICIPATION OF MANAGEMENT

Second only in importance to the selection of instructors is the part played by plant management. Without its full support and active participation, a training program will result in a halfhearted effort no matter how completely other requirements are fulfilled.

As a period of time is required before the benefits of training become apparent, intermediate plant supervisors must be continually "resold" on the value of the program. This is made even more difficult because the loss of instructors and students from schedule work is an immediate sacrifice. It should be made clear to any who might oppose the reopening of classes that the effort is to be continued and that continued objection will only delay the realization of an improved manpower situation.

If management were to establish a policy of including in engineering schedules a minimum allowance for upgrade training, loss of instructors, etc., little opposition could be offered. If such allowance can be made for sickness and vacations, it could also be made for a minimum amount of continuous training.

We are also taught that one of the principal responsibilities of supervisors is to know the capacities of those under them and to further actively the development of their ability. How many of the vast number of newly appointed group leaders

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recognize this? Very few of them make a real effort to promote interest in the training offered.

In an attempt to overcome this stagnation the "training timetable" in TWI'S Job Instructor Training has been employed to advantage. This method, in addition to overcoming the supervisor's neglect in personnel development, will provide valuable information for engineering planning and scheduling.

STUDENT SELECTION

Student selection also has an important bearing on the ultimate value of any training program. We at Consolidated Vultee have long recognized its seriousness and have directed an appreciable amount of study toward its solution. Though admittedly not prepared to offer a final solution, it is believed that these studies have indicated possible improvements.

A troublesome factor in student selection arises from a prevalent neglect on the part of the student of building a firm foundation of fundamentals before progressing to more advanced subjects. Among employees applying for such courses as stress analysis, aerodynamics, etc., this tendency is especially noticeable. It also occurs far too frequently among those who wish to be accepted for company-paid upgrading courses.

Applicants sometimes have taken the preparatory courses, but owing to the time that has elapsed and their lack of frequent use of the material, few can keep up with the more advanced work. This usually results in the student dropping from the class. If enough of these "drops" occur, and they frequently do, the class must be discontinued for the lack of a permissible minimum number of students. Such incompleted classes exasperate those who were qualified and this results adversely on the entire program.

Various methods have been tried to impress applicants with the necessity for proper preparation. However, only one of these has shown any degree of real promise. It consists of giving the applicant, for a company-paid course, a qualifying test for the purpose of determining whether or not he is able to handle fundamental principles required in the course. If he completes the test satisfactorily, his supervisor is then contacted to determine the employee's attitude toward his work and his desire to further himself by outside effort. Only when investigation indicates that a company-paid training course is justified is the employee accepted. Frequently, however, the results of the test show that the applicants cannot solve the simple problems. When this occurs, they are interviewed carefully, the test reviewed and explained, and recommendations made as to the training needed to qualify at a later date.

In this way paid courses are strengthened in that only those having at least a minimum background may enter. Such selection not only maintains a uniform level of qualifications in the class but lends extra incentive to those who fail to qualify. At any rate this method of recruitment gets the people in training, and in the right courses. Even with a demonstrated lack of ability in basic concepts, the success of an interview between employee and educational counselor seems to depend upon a combination of cajoling, bullying, and coaxing. They hate to use their own time to go to school.

In testing over two-hundred persons who were thought to be qualified for upgrading courses, it was found that a surprisingly large number who had recently taken part-time courses or who recently had completed college engineering courses were unable to do some of the simplest problems. Among these were men having one to four years' experience in aircraft design and layout.

It has often been said that the importance of formal schooling lies in the fact that once a student has taken a subject, he will always know where to find his material when suddenly confronted with the need for it. Many students have been thoroughly indoctrinated in this precept, oftentimes to the extent of relying upon it to retain even the most basic principles. It is true that it is impractical to attempt to remember everything learned in school and that references must be resorted to frequently. However, experience has shown that too many engineers depend upon references almost entirely, or still worse, neglect even that.

For example, recently it was found that an individual having four years of mechanical-engineering training and one year of experience in engineering layout was stopped by a problem involving nothing more than finding the true angle between two structural members. After having puzzled over this four hours and having made a complicated model of cardboard, staples, etc., he finally had to question a descriptive-geometry instructor to obtain a solution. He could have, with very little trouble, referred to a text. The point is, the fundamentals of finding the true angle between two intersecting planes should have been so deeply ingrained in him that he could have reasoned out the process easily. He was probably another one who accepted too literally someone's remark that one should not attempt to remember it all, that he should depend upon references.

It is small wonder that so many people are needed to design an airplane if books have to be consulted for principles as basic as this. It is ardently hoped that instructors and professors will emphasize more strongly in class the necessity for students to be thoroughly grounded in the underlying concepts of the subjects they study.

COURSES SHOULD DEMONSTRATE APPLICATIONS OF PRINCIPLES

Training courses which have been most successful in filling the wartime requirements of industry are those in which the major portion of time and effort is directed at practical application of principles. Representative problems, typical of the work the student will do in the plant, have been used in a manner which simulated, as closely as possible, that used on the job. No, this is not vocational training necessarily, but training stripped of any furbelows which cannot contribute to an early peace. After all it was because of this war that this training became necessary and the war is still primarily an immediate problem.

In view of test results, previously mentioned, in which even college engineering students failed to excell, it would appear that even in peacetime a greater effort toward the practical application of principles would contribute greatly to design effectiveness. As it is, principles usually learned the third and fourth year of college are completely forgotten by the time the student has an opportunity to apply them.

Another exasperating problem, when interviewing prospective students, is heralded by the excuse, "It has been so long since I studied this subject and I have so little use for it that I have forgotten it." In such cases an attempt is made to impress each person with the value of the knowledge lost and the investment in time necessary to relearn it.

If he can be impressed by this, he is then urged to develop a constructive plan for retaining that which he has once learned. As an illustration of such a plan, he is urged to devote an hour and a half a week on a set evening reviewing the various subjects he has already taken. He is assured that if continued indefinitely this review will keep fresh in his mind many principles which he may be called upon to use at a moment's notice. This weekly review corresponds to a systematic method of saving money. The man who makes a practice of saving a dollar a week will have a much larger bank account in the long run than the man who saves spasmodically.

Unless a training program is closely co-ordinated with the supervisors in the plant, and has their full understanding and support, it is not fully effective.

Supervisors, after all, are expected to use the students upon completion of the classes. If they disagree with methods and procedures taught and attempt to reteach the material, valuable time has been wasted. It is the educational supervisor's job to see that this does not occur. He must see that a common under-

(Continued on page 612)

Postwar CIVILIAN READJUSTMENT TRAINING

By J. C. WRIGHT

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ONE of the major characteristics of vocational education is summed up in the word "flexibility." In this constantly changing world of ours, no vocational-training program can remain static for any considerable length of time in any community. It must always be on the alert to changing conditions. With the advent of the present war, vocational education was called upon to adjust its program quickly, almost overnight, toward greater emphasis upon training for war production.

The war has accentuated the problem of vocational training. The conversion of industries from peacetime production to production of supplies and materials essential to winning the war will soon become a historical fact, and these same schools will be called upon to reconvert themselves to the problem of mobilization training in reverse.

On July 1, 1940, the public vocational schools were given funds to inaugurate a program of training men and women to work in essential industries. These funds have been continued during the ensuing years in greater amounts, as the need became more evident. More than 6,000,000 persons have been trained as wage earners in war industries. More than 2,000,000 persons have been trained to increase food production on the farm, and to repair farm machinery for which replacements could no longer be obtained. With the coming of peace, these programs, along with demobilization, will need to go into reverse and assist the millions who have learned a single operation or skill for war production to readjust themselves, to improve their chances of employment in peacetime by broadening their skills and technical knowledge.

SCOPE OF POSTWAR OCCUPATIONAL ADJUSTMENT WILL BE GREAT

According to advance forecasts of changes in the labor force from war to peace, it is to be expected that between 8,000,000 and 10,000,000 persons will leave the armed forces, that from 6,000,000 to 7,000,000 will leave munitions industries, and that from 1,000,000 to 3,000,000 will leave other nonagricultural employment. A total of from 10,000,000 to 20,000,000 persons will therefore probably be in need of making some form of occupational adjustment within a very short time after the war has ended.

We all hope that our leaders in Government, in war, in industry, and in labor will be able to devise some plan by which the reconversion of industries from war production to peacetime production will not be so abrupt as was recently the case in the Brewster plant. A more gradual conversion will provide a minimum of time during which not only industry can retool, but engineers can plan and make ready for the production of new products calling for new markets and new machines and newly trained personnel.

It has been estimated by the Bureau of Labor Statistics that there are 2,800,000 extra persons in the labor force who normally would still be in school but who are now at work or in the armed forces. This huge body of untrained youth, most of whom have never held a wage-earning job, represents a backlog of vocational training which cannot be neglected. The Army has trained these youth to preserve the ideals and institutions for which we stand. When they come back from war, they will be 2 to 5 years older in years, but perhaps 5 to 10 years older in their thinking and in their willingness and desire to settle down and establish themselves as heads of families. To do so it will be necessary that they have adequate wage-earning capacities. The greatest gift that our Government could extend to them would be in the form of an ability to earn a good living throughout the remaining years of their lives.

PLANNING POSTWAR VOCATIONAL-TRAINING NEEDS IS A COMPLEX JOB

The postwar needs of business, industry, agriculture, and the home are uncertain and very complex. To provide the right kind of job training for the right persons, we must have answers to certain questions confronting us, which otherwise obscure the outlook. For example:

(*a*) To what extent will there be job transfers within and between industries?

Statistics such as those given on the net contractions in various components in the labor force do not have all of the occupational readjustments which will take place. Even among persons remaining in employment, there will be many shifts from one industry to another, or from one job to another. The extent of these shifts will not be the same in all industries and in all parts of the country.

(*b*) Peacetime vocational-training objectives must be broad. Training for war occupations was largely one of meeting a temporary need. Many persons in war production will not have the skills required for peacetime employment. While many occupations are declared nonessential in wartime, gainful employment during peacetime embraces a wide range of occupations.

(*c*) Training demobilized veterans. Congress now has before both Houses legislation which would provide financial assistance to demobilized war-service personnel for their education and training. It is expected that this legislation will soon be enacted into law. It has been estimated that 85 per cent of the persons seeking training will want vocational training. For such a program alone our vocational schools will find it necessary to do careful planning and to make many readjustments in equipment and teaching personnel.

VARIOUS STUDIES AND INVESTIGATIONS

On June 1, 1944, the U. S. Commissioner of Education approved the report of the Consulting Committee on Vocational Technical Training and ordered 20,000 copies to be printed for general distribution. The report represents about 15 months of work by a committee on which representatives of labor, management, public vocational schools, and engineering colleges were members. The report is largely concerned with types of technical training not heretofore provided except in certain technical institutes, junior colleges, and other more or less incidental programs operated by public vocational schools and

(*Continued on page 592*)

Abstract of address contributed by the Postwar Training Committee on Education and Training for the Industries and presented at the Semi-Annual Meeting, Pittsburgh, Pa., June 19–22, 1944, of The American Society of Mechanical Engineers.

Assisting MARINES *Back to* CIVIL LIFE

By LIEUT. COL. C. B. RHOADS

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THE problem of readjusting to civilian life, those who even now are being discharged from the services, is a vital and urgent one. It is no military secret that the U. S. Marine Corps, during the past 6 months, has planned, organized, and put into effective operation, a rehabilitation program.

The attitude of the services to the problems of the veteran should be fully known and fully discussed. There should be mutual understanding between the services and all agencies devoted to the task of rehabilitation. The limitations of their respective functions should be clarified; for unless there is a complete co-ordination of all rehabilitation operations, from the moment a man is a combat casualty or is up for discharge, until the fact of rehabilitation has been accomplished, confusion will result, there will be a repetition of the tragic mistakes of the last war, and the veteran will fall victim to the wiles of the first selfish pressure group which seems to offer him a quick answer to his difficulties.

This is not a figment of the imagination. We know it is a thing which has happened before. It may happen again unless there is immediate recognition of the existence of a real emergency requiring not only planning, but action; and, above all, a complete co-ordination of rehabilitation activities to avoid dissipation and duplication of effort.

The paradoxical fact that, at a time when the war has not yet approached its final stage and the victory has not yet been won and while thousands of men are still being inducted into the armed forces, over 1,000,000 men have been separated from the services, has created an emergency of no small proportions. In face of this fact, neither the services nor civilian or governmental agencies can afford to await the termination of hostilities before putting into effective operation procedures to protect the future welfare and assure the civilian readjustment of this vast contingent of veterans who must even now be reabsorbed into our civilian economy.

MANY BENEFITS AVAILABLE TO SERVICE MEN

Months ago it became apparent that men were being discharged without any sound knowledge regarding their rights, privileges, and benefits as veterans. Valuable insurance rights were being sacrificed for want of adequate information. Men were returned to their homes unaware, in many instances, of their obligations to Selective Service, of their opportunities for re-employment through the United States Employment Service, or of the privileges which they possessed for hospitalization or vocational training through the facilities of the Veterans Administration. The result was often disillusionment and resentment instead of pride in the sacrifices of service to country, bewilderment instead of enthusiastic interest in the future.

The establishment of the Rehabilitation Division at Headquarters, Marine Corps, on November 18, 1943, was our answer to the persistent challenge of how to handle, with justice and consideration, the problems of readjustment to civilian life of the men now being separated from the armed forces who have served faithfully and sacrificed much. This division is charged with the administration of cases of discharged or demobilized marines, men and women, involving rehabilitation, vocational training, re-employment, hospitalization, pension claims, and other matters which may affect the rights, privileges, and benefits of marines honorably separated from the service. In the performance of such functions, the division is to maintain active operating liaison on a local, state, and federal level between the Marine Corps and the governmental and other agencies organized for the rehabilitation and welfare of former marines.

FUNCTION OF REHABILITATION DIVISION OF MARINE CORPS

The primary mission of the Rehabilitation Division is to assist and advise the marine at the time of discharge in the complicated problems incident to a return to civilian pursuits. This involves a conscious departure from traditional thought regarding the obligation of the services to discharged personnel. It is, of course, obvious that the job of the Marine Corps is to train men to fight, to become effective combat marines; but, if this is total war, involving complete mobilization of all human resources, it should no longer be said that the responsibility of the services ceases the moment a man is discharged, and that there is no duty on the part of the services to prepare a man, before discharge, for the tremendous impact involved in the return to civilian life. The services cannot ignore their moral obligation to assist the man at the critical point of separation.

To discharge a man without some adequate preparation for civilian readjustment may be as fatal to his future as sending him into combat without teaching him how to shoot. In either case the Marine Corps intends to take no chances, and if advice from his own service can help turn the trick, that assistance will be given. We seek to meet that moral obligation without trespassing upon or duplicating the activities of existing civilian agencies.

It is the intention of the Marine Corps to see to it that no man is separated from a service to which he has given full measure of faithful devotion without a personal interview with one in the uniform of his service specially trained and competent to advise him regarding his problems of personal or economic readjustment. In each of the twelve Marine Reserve Districts in continental United States, a specially selected and trained commissioned officer has been attached to the Marine Corps District Commander. To the staffs of these District Rehabilitation Officers have been assigned enlisted interviewers who have been specially trained in rehabilitation procedures and have been schooled in the operations of all civilian agencies charged with the duty of civilian readjustment, such as the Veterans Administration and the United States Employment Service.

These enlisted men, selected from the rank and file of the Marine Corps, are of outstanding character and educational qualifications. They are technically trained but speak the language of the marine, think his thoughts, and know his life.

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They are able to give him an expert judgment which may assist in the process of mental readjustment which all men will experience on their return to civilian life.

Through continued operating contacts between the District Rehabilitation Officer and the Veterans Administration, the U. S. Employment Service, State Re-employment Divisions of Selective Service, state rehabilitation services, local clearinghouse committees of the Veterans Employment Service, the Navy Educational Service Officer, the Red Cross, and local industrial and civic groups, complete information regarding job and educational opportunities will be constantly available to the marine prior to discharge. The marine's interest in his own personal problems of readjustment thus will be developed long before the time of actual separation from the service. The questions which will arise cannot be dismissed or solved by a perfunctory interview. The local rehabilitation procedure has been developed on a personalized basis with a firm recognition that the problems of men and women are as different as their individual characters and must be handled as such.

GUIDANCE, THE BASIC CONCEPT OF PROGRAM

A word as to the basic concept of our program. As we view it, rehabilitation is the process of "restoration to privileges," the privilege of a sound body, the privileges of free citizenship temporarily lost through service to country. Unless a man knows what those privileges are, he will not be equipped to meet the responsibilities of citizenship. If we are to avoid the tragic spectacle of men returning to civilian life cynical, disillusioned, and maladjusted to society, we must give to the discharge procedure the same dignity which accompanies entry into the service. It is not enough to wish a man well when he is discharged, to tell him he is a veteran and that he must now seek advice only from established civilian agencies. A man's first impact with the problems of readjustment should come from someone in his own service whom instinctively he will trust and respect.

So frequently today that first impact comes through interviews by civilian representatives of civilian agencies. Nothing has preceded this interview to cushion the impact, to adjust the man's mind to the realization that, in the wisdom of the Government, these vast civilian agencies have been established in recognition of an obligation to the veteran, not to give him charity. In the past there has been nothing to counteract the conclusion that the interest of the service in the man's future ceases with the delivery of the discharge certificate.

Such a tragic reflection can be avoided when it is known that a man awaiting discharge may expect to be interviewed by a competent officer whose duty it is to assist him in bridging the gap between a life of military discipline and his return to a civilian career, ofttimes with a physical handicap which might affect his ability to assume the privileges and duties of citizenship. Whatsoever the services can do to help in this process should be done. It is no answer to say that there is no legal obligation to do so. Many a man in combat is pulled together because an officer or a buddie gives a word of encouragement at the right time. Legal obligations do not enter into the picture where human values are in the balance.

It is true that the marine does not have to file a pension claim. He doesn't have to get a job, and he may not want to avail himself of any of the opportunities which may be offered to him for rehabilitation. These are all privileges which can be exercised by him only on a voluntary basis. But the fact remains that he should be informed by competent service personnel, prior to discharge, regarding his rights and privileges as a civilian when such information is available. If he needs and wants advice, it should be available. To reorient a man or bring him into correct relation to the problems of civilian readjustment is merely completing the cycle of his military life. Whether he accepts the opportunities available, or follows the advice given, is a matter for his free and voluntary choice.

CO-OPERATION WITH CIVILIAN AGENCIES

The knowledge that the Marine Corps has assigned to duty in each Reserve District a competent Rehabilitation Officer with adequate personnel to assist him at all points of discharge will at once lend dignity to the separation procedure. It will instill in the marine an inquisitive interest in his future. It will demonstrate that the Marine Corps does not intend to let him down. The endorsement by the services at the time of discharge of the activities of civilian rehabilitation agencies, a careful explanation of how their operations will fit into the pattern of a man's future life, will go far toward insuring the effectiveness of the work of such agencies. The Rehabilitation Program of the Marine Corps is geared to implement, not duplicate, the work of other agencies.

We are fighting for the preservation of the privileges of free citizenship in a democratic world. That fight will not be over until the marines who did the fighting are restored to those privileges. The Marine Corps is determined to assist its men and women to gain a sound footing on the way back.

Postwar Civilian Readjustment Training

(*Continued from page 590*)

engineering colleges. It aims to fill the gap between graduation from the secondary school and the engineering college. In this area probably 75 per cent of the graduates do not enter colleges and universities. They go directly into employment and with their secondary-school background can be trained in one or two years for employment in a technical job for which the survey revealed 5.2 individuals are needed for every engineering-college graduate.

Another committee appointed by the U. S. Commissioner of Education last January, is responsible for making studies and investigations of postwar vocational-training problems. A great many of these problems are already confronting the state and local authorities responsible for planning reconversion vocational-education progress.

In all of this planning, the co-operation of management, labor, and schools is essential. An adaptable and flexible industrial-education program must be responsive to new developments in such fields as plastics, electronics, and aviation, which are to be expected after the war. Likewise, agricultural education must be adapted to such technological developments as those in the processing, preserving, and packaging of foods; in the development of higher seeding strains and varieties of crops; in disease and insect control; in new machines and labor-saving devices; and in the improvement of livestock and breeding. In these and in the field of business education, new training areas must be discovered and modification in training programs outlined.

CONCLUSION

We are told that fully 6,500,000 workers, who normally would not have been employed, have come from retirement, from institutions, from homes, to help in war production. In 1940, there was a conservative estimate of 8,000,000 unemployed. When the war ends, we will need to find new work opportunities for this group, for no one can be content to look forward to another period of great unemployment. If the 6,500,000 not normally employed, or any considerable part of them, insists on remaining at work in wage-earning pursuits, the problem of management, of government, and of labor will be materially increased over the unemployment problems of 1940.

CRACKING *and* EMBRITTLEMENT *in* BOILERS

By H. N. BOETCHER

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DETERIORATION of the component parts of a steam-generating unit represents one of the major problems in the production of power and heat. The occurrence of numerous types of "wet" and "dry" corrosion, of cracks, and of so-called embrittlement complicate the problem. With all of these factors complex and involved, one source of confusion is a tendency to ascribe all cracking or embrittlement found to some one cause. An attempt will be made, therefore, to list and describe, for identification, the characteristics of the principal types of cracks, cracklike penetrations, and embrittlement found in pressure parts of boilers, with particular emphasis on caustic cracking and a recently discovered type of cracks in high-pressure boilers. Since only fundamental types will be covered, cracks such as "fire cracks" which usually represent either creep or corrosion fatigue will not be referred to separately.

CRACKS, PENETRATIONS, AND EMBRITTLEMENT

Definitions. The term "embrittlement" frequently has been used in cases involving only cracks. "Brittleness," however, designates a physical condition of a material, denoting low resistance to shock-type stresses. "Embrittlement" therefore should be used only to refer to a change in the physical properties of a material which, originally tough, loses this toughness due to some effect of manufacturing or service conditions. "Cracking" denotes actual rupture within the material. "Embrittlement" and "cracking" may occur separately or in combination. For the sake of consistency, this paper will adhere to this differentiation even though this involves the use of terms such as "caustic cracking," in place of the customary "caustic embrittlement."

Regarding "cracking," the course of a crack is one of the factors indicating the type of failure. It may pass between the "grains" or "crystals" of the steel ("intercrystalline") or may cut across the grains ("transcrystalline"). The fracture of a room-temperature tensile-test specimen is transcrystalline, indicating the path across a grain to be mechanically weaker than the grain boundaries. The boundaries, however, are chemically weaker under corrosion attack and become mechanically weaker at high temperatures.

Folds. A borderline form of "cracking" frequently encountered in plates and tubes and mistaken for service cracks is shown in Fig. 1. This apparent "cracking" is the result of inclusions of gases, or other foreign matter, in steel. During rolling, the metal at such inclusions is folded over and forms these fissures. These defects are potential starting points for service failures and are therefore always undesirable. Numerous folds of small depth, however, have been found in material which had been in successful service for many years and in which the folds had not caused trouble, due to the absence or low magnitude of stresses or conditions which would develop cracks from such starting points.

Aging. After deformation at or near room temperature, some initially tough steels become quite brittle in service, especially after prolonged heating to temperatures from about 200 to 600 F. The time and degree of embrittlement depend upon various factors, such as type of material, degree of deformation, service temperature, etc. The condition represents a true "embrittlement," as already defined, and the material may have very low impact strength.

FIG. 1 "FOLDS" AT INNER SURFACE OF SEAMLESS-STEEL BOILER TUBE; ×500

As long as there are no cracks, toughness of the steel can be restored by proper heat-treatment. It is believed that the brittleness is caused by a precipitation of carbides along crystallographic planes where slippage took place within the grains distorted by cold-working. During this deformation, the grains are strained and hardened. The precipitated carbides usually are of submicroscopic size. The precipitation causes further hardening and increase in tensile strength of the steel but lowers the ductility and especially the toughness as expressed in impact strength. Metallurgical progress, particularly the use of killed steel in tubing, has resulted in a decrease of troubles of this type in recent years. There still are cases, however, of the rolled and flared ends of boiler tubes becoming so brittle that a light hammer blow will break them like glass. The failure of bolts on dismantling or tightening after service at low and moderate temperatures in boiler applications also is likely to be of this type. A fracture resulting from aging brittleness normally is bright and "crystalline" until darkened by corrosion. The crystalline appearance is caused by the transcrystalline failure along the crystallographic planes which act as reflecting surfaces for light.

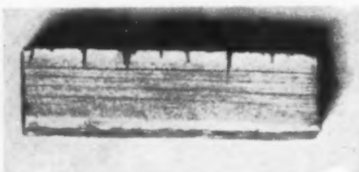
Corrosion Fatigue. A sufficient number of alternating stresses caused by vibrations or other mechanical or thermal variations, above a minimum stress fluctuation which depends upon material and type of stress, will cause cracks which, in steel, normally are transcrystalline. This type of failure is called

"fatigue" and does not involve a change in physical properties or a "tiredness" of the metal, but actual cracking. Within limits, the "fatigue strength" of a metal, which is the minimum variation in stress to cause the failure of a carefully prepared laboratory specimen, is of less importance than local concentration of stresses as a result of design, workmanship, or service conditions.

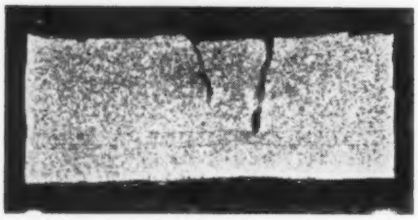
Failure is accelerated for most materials by the presence of a corroding medium, such as water. Corrosion, in this case, develops points of stress concentration at the surface and penetrates into the metal with the crack. As a result, the physical appearance of a "corrosion-fatigue crack" differs appreciably from that of a "fatigue crack."

As an obvious result of operating conditions, corrosion fatigue is far more frequent in pressure parts of boilers than straight fatigue failures, although the latter develop occasionally in branch cracks or under other special conditions. The blunt form of many corrosion-fatigue cracks is shown on etched cross sections in Fig. 2(*a*) and (*b*), at low magnification, and in Fig. 3, at higher magnification. The latter also indicates the corrosion products filling the crack. It is probable that the appearance of the cracks indicates the relative effects of stress and corrosion, with the crack, shown in Fig. 3, representative of a preponderance of corrosion and the narrower branching cracks, shown in Fig. 4, indicative of higher stresses.

The course of a fatigue or corrosion-fatigue crack is determined, to a large extent, by the direction of the stresses. A



(*a*)



(*b*)

FIG. 2 CORROSION FATIGUE CRACKS

(*a*, Header wall, 0.5 in. thick. *b*, Boiler-tube wall, 0.22 in. thick.)

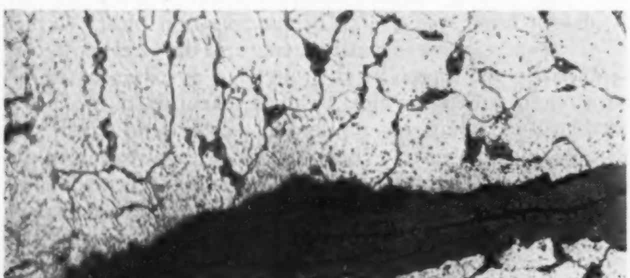
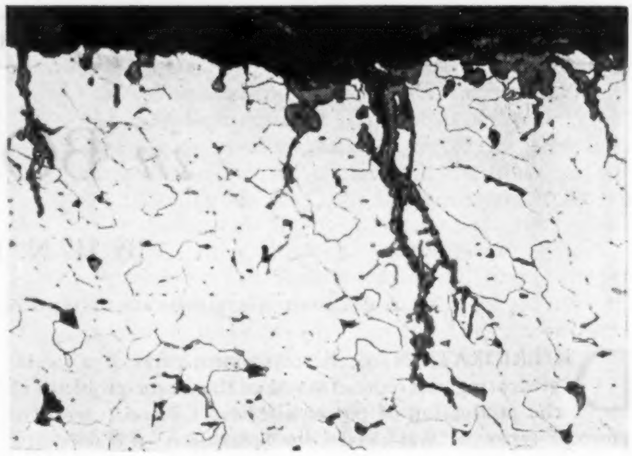


FIG. 3 END OF CORROSION-FATIGUE CRACK IN BOILER TUBE; ×500



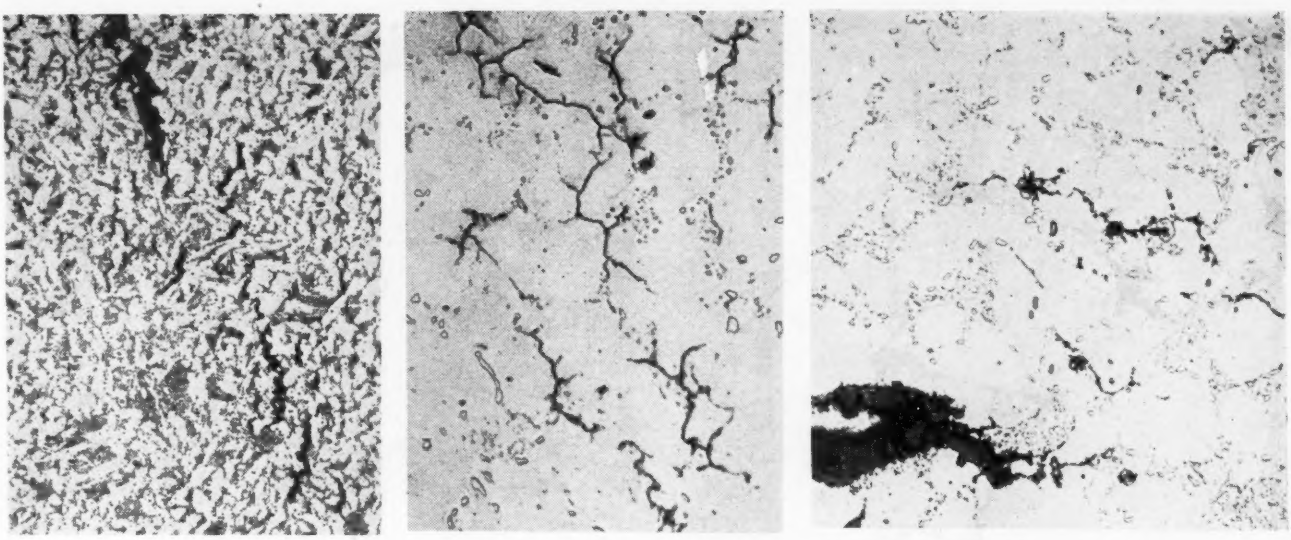
(*a*) ×200

(*b*) ×500

FIG. 4 CORROSION-FATIGUE CRACKS IN BOILER TUBES

fatigue crack, in general, follows the path dictated by the direction of the maximum stress at the momentary end of the crack, as modified by weaknesses in the material. This applies also to corrosion fatigue. Both types of cracks are transcrystalline. The fracture of a corrosion-fatigue crack normally is obscured by iron-oxide scale and does not show the typical progress lines of a plain fatigue failure.

Creep Cracks. The phenomenon of creep in steel at elevated temperatures has received considerable attention by research workers, designers, and operators ever since high temperature became a technical tool for raising output and efficiencies. The term "creep" is used to designate the slow plastic flow of steel under stress at temperatures rendering the particular steel susceptible to such yielding. Depending upon stress, temperature, and material, steel under creep may ultimately fail by cracking. If the stress, as related to the temperature to which the steel is exposed, is high, cracking will develop sooner, but after greater total deformation of the steel than with lower stresses. Due to the weakness of grain boundaries at elevated



(a) ×100 (b) ×500 (c) ×500

FIG. 5 CREEP CRACKS IN STEEL BOILER TUBES

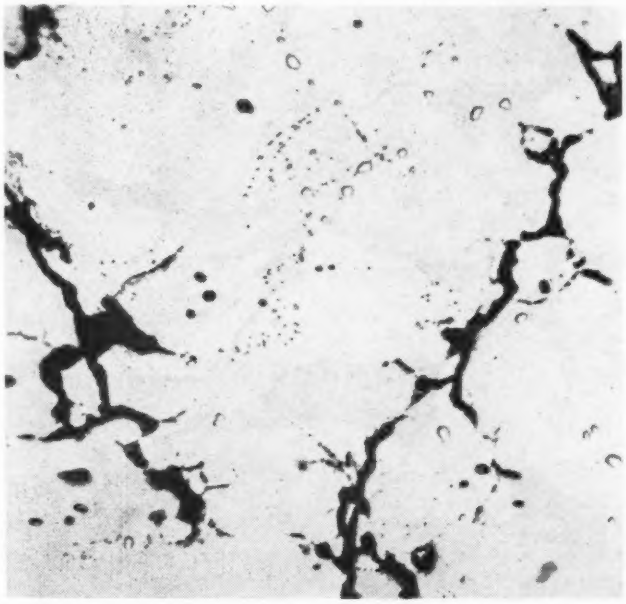


FIG. 6 WIDE CREEP CRACKS IN STEEL BOILER TUBE; ×1000

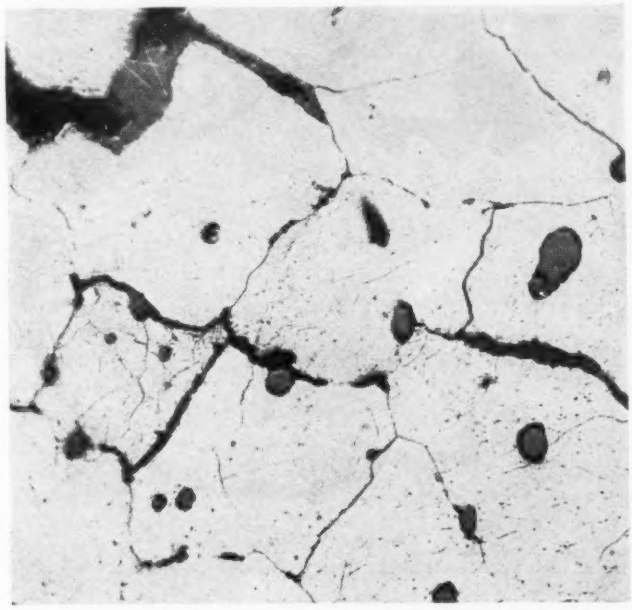


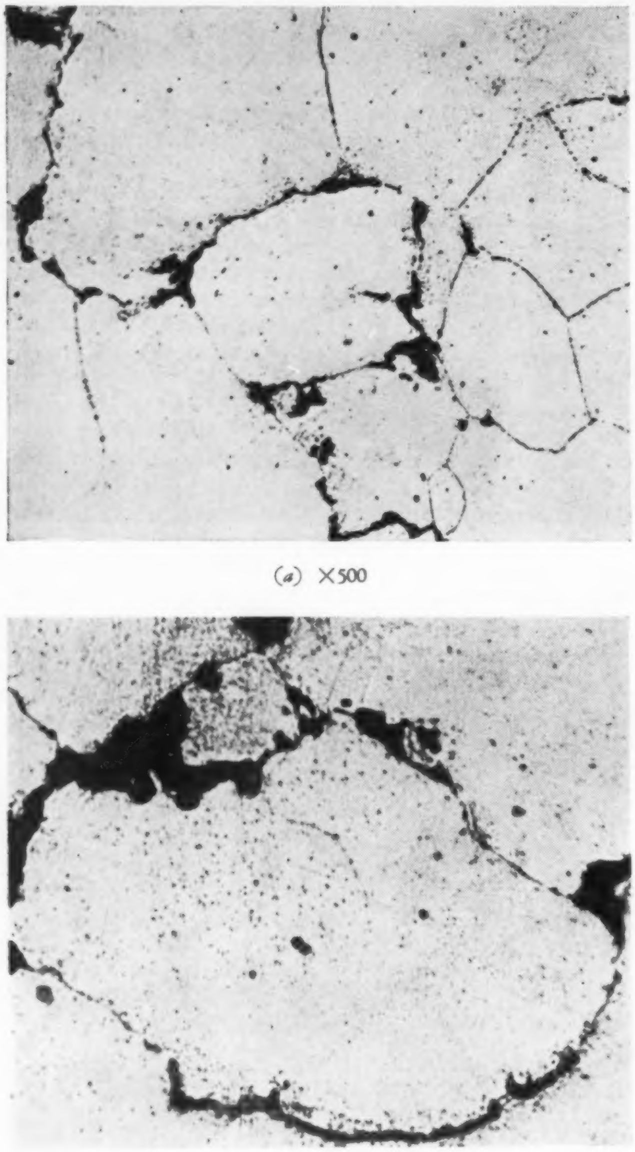
FIG. 7 CREEP CRACKS IN WROUGHT-IRON BOILER TUBE; ×500

temperatures, cracking develops by separation of the grains from each other and the cracks are intercrystalline.

Again, the appearance, distribution, and number of the cracks are indicative of the conditions under which failure occurred. One extreme is the longitudinal splitting of a bulge in a tube. The bulging results from localized overheating of the steel, as caused by scaling, insufficient circulation which causes steam to form and remain at the particular location, or by exterior application of excessive heat, which lowers the strength of the steel. With the stress high, relative to the metal temperature in the bulge, the split occurs with thinning of the steel into a sharp edge and represents a short-time tensile-test failure at high temperature rather than a creep crack. There are many transition steps from this type of split to the numerous cracks formed slowly in sections exposed to stresses relatively low at the particular temperature.

Since most creep failures occur at temperatures above 900 F, the carbides of the steel usually have been spheroidized before cracks develop. Exceptions to this "rule" have been found primarily in carbon steels which are more likely to be used in service below 900 F. The direction of the cracks again is determined by the direction of stresses since the failure is a result of stress. Since the actual cracking results from stress and since, furthermore, the stresses within the steel may be quite complex at any one point, the cracks may show appreciable variations in direction locally. Creep cracks are shown in Figs. 5 to 7.

Intercrystalline Oxidation. A border line between general corrosion which may show some intercrystalline penetration and cracking is represented by intercrystalline oxidation. It has been found in superheater or boiler tubes overheated excessively as a result of loss of water or steam flow by plugging or other causes, or of operation of superheaters with high gas temperatures before flow of steam has been established. Failure usually is the result of weakening of the tubes by loss of metal or loss of strength, at the high temperature, rather than of the intercrystalline oxidation. The importance of the latter is in its indication of overheating rather than as a direct cause of rupture. Steel corroded to this extent cannot be made serviceable again by heat-treatment. Fig. 8 shows intercrystalline oxidation of a superheater tube.



(a) ×500

(b) ×1000

FIG. 8 INTERCRYSTALLINE OXIDATION OF SUPERHEATER TUBE

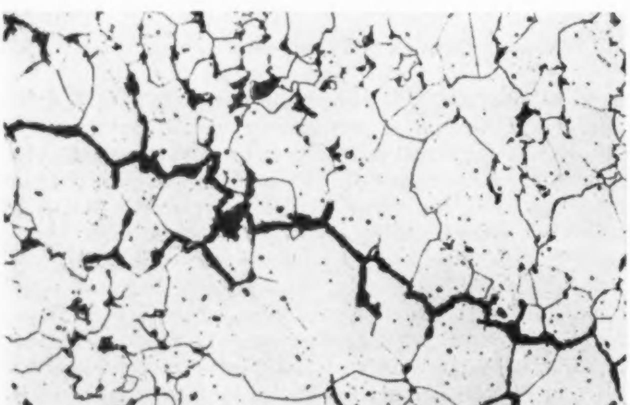
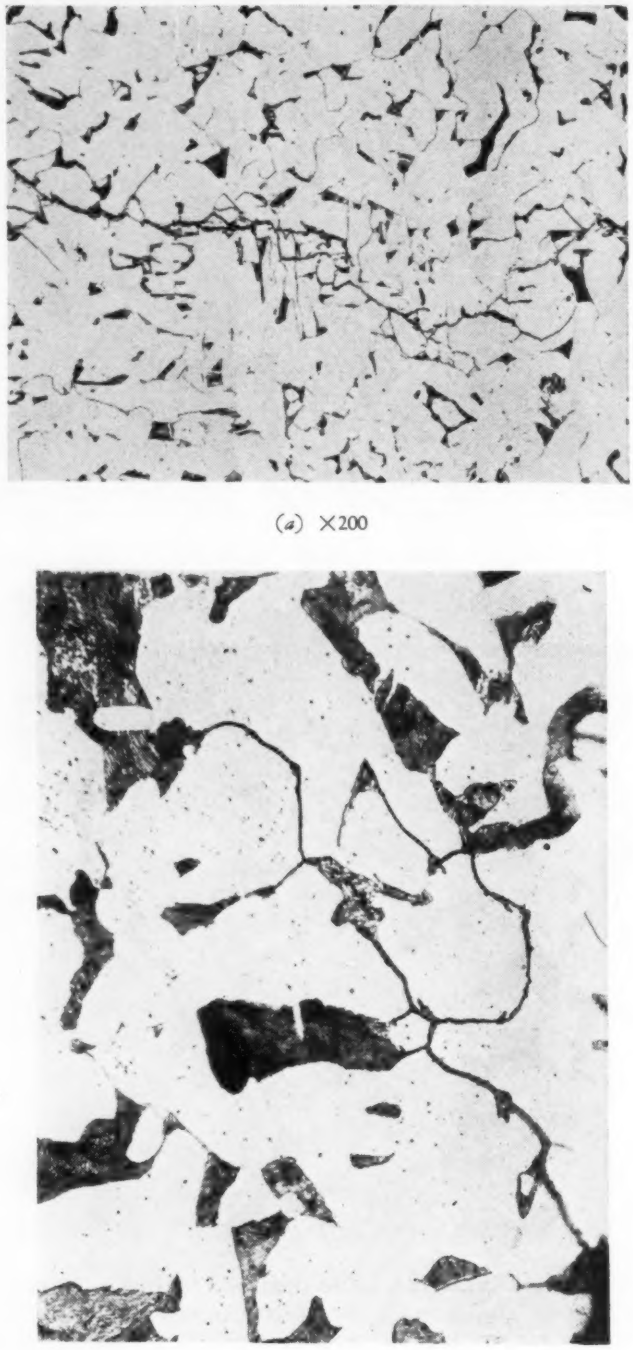


FIG. 9 CAUSTIC CRACKING IN RIVET; ×200

Caustic Cracking. Even though other types of cracking probably cause more failures, at the present time, the so-called



(a) ×200

(b) ×500

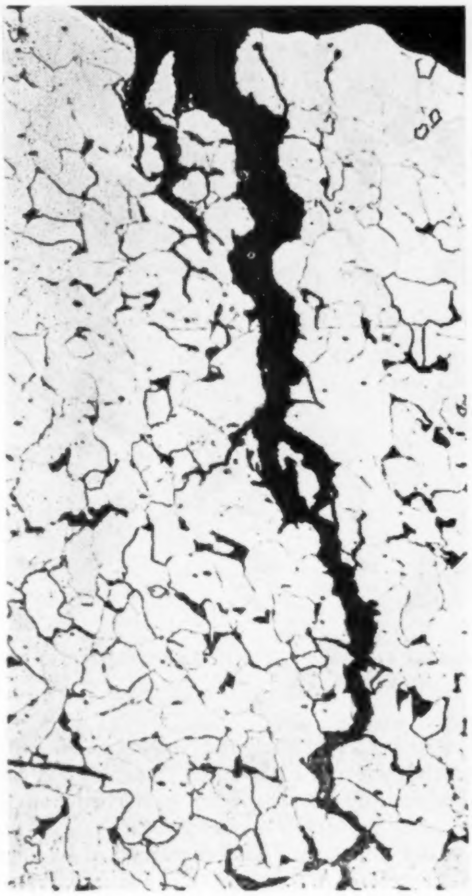
FIG. 10 CAUSTIC CRACKING IN HEADER PLATE

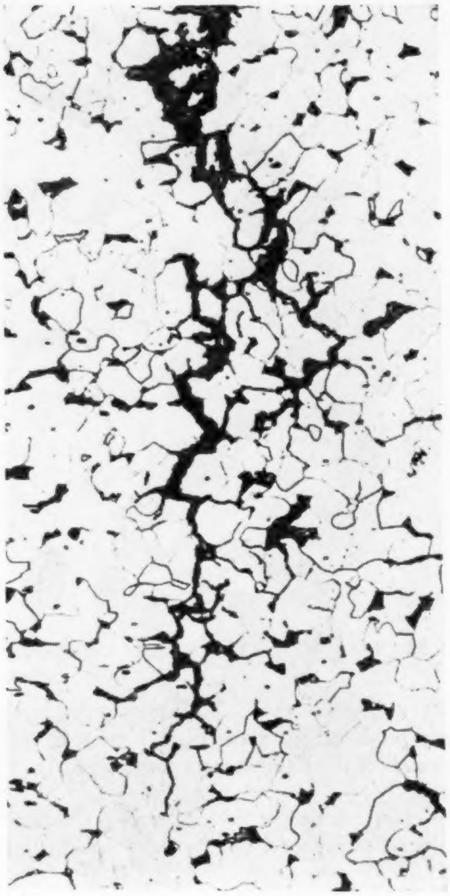
"caustic embrittlement" has managed to gain and maintain a unique position due to disastrous experiences in the past and is even referred to occasionally as "the" boiler embrittlement.

Caustic cracking has been experienced only at low and medium pressures. It always occurs at highly stressed points in steel exposed to a concentration of boiler-water salts. Regarding causes and remedies, reference is made to the extensive literature on this subject since the scope of this paper is limited to the characteristics of the failure itself and, accordingly, to means of identifying it.

CAUSTIC CRACKING A TYPE OF STRESS-CORROSION FAILURE

Most research workers agree that caustic cracking is essentially a type of stress-corrosion failure. It appears that both the magnitude of the stress and the degree of aggressiveness of





(a) (b)

FIG. 11 CAUSTIC CRACKS DEVELOPING AND BRANCHING FROM CORROSION-FATIGUE CRACKS; ×200
(a, Main crack developing into caustic crack. Caustic branch cracks. b, Large caustic branch crack.)

corrosion are critical and must be within certain ranges in order to combine to cause this type of cracking. According to some investigators, the stress must exceed the yield point of the steel. It seems well established, in any case, that the stress must be high and, at least, near the yield strength before failure will occur. As far as the corrosive attack is concerned, it is probable that it must be relatively mild. Severe corrosive action is more likely to result in general corrosion. Since the grain boundaries are chemically weak, corrosion tends to attack the boundaries first, a trend which is observed frequently in boiler corrosion, although it is obscured in many cases of general attack.

The relative magnitudes of stress and corrosion again affect the course of the cracks. Caustic cracking usually follows grain boundaries but occasionally cuts across grains when the mechanical resistance of the grain is less than the chemical resistance of the grain boundary at the particular point and with the particular local balance of stress and chemical action. Caustic cracks are substantially intercrystalline, but almost always have some transcrystalline sections (Figs. 9 and 10). The latter increase with increasing stresses and are therefore usually found to a greater extent in caustic cracks produced for test purposes in specimens at an accelerated rate than in service cracks.

The required concentration of boiler-water salts may be produced at any point at which leakage or other conditions result in the evaporation of the water in a confined space. With water having the necessary characteristics, riveted seams, especially when calked on the outside, and rolled tube joints are particularly likely to develop caustic cracking at leaks. Concentration may also take place in cracks or fissures produced by other types of attack. Fig. 11 (a) shows a corrosion-fatigue crack produced by alternating stresses superimposed on a continuous bending stress in a boiler tube at a leaking rolled joint. Concentration of salts in the crack, together with the bending stress, produced intercrystalline caustic branch cracks at the corrosion-fatigue crack and finally changed the main crack itself to a caustic crack about 0.016 in. below the surface. The caustic branch crack of another corrosion-fatigue crack is shown in Fig. 11 (b) and has all of the characteristics of caustic cracking.

A recently published paper by Dr. C. A. Zapffe,[1] based largely on a study of the literature, contends that caustic cracking is essentially the same type of failure as found in the embrittlement and cracking of pressure vessels by atomic hydrogen in certain chemical processes. Since such a similarity would imply the use of similar corrective steps, it is important that the differences be understood. With space too limited for a detailed discussion of Dr. Zapffe's paper, attention is called to the following fundamental differences between hydrogen embrittlement and caustic cracking:

1 Caustic cracking has been observed only at low and medium boiler pressures, with decreasing frequency at increasing pressures. At corresponding temperatures, hydrogen embrittlement is substantially transcrystalline. Caustic cracking is predominantly intercrystalline.

2 Contrary to Dr. Zapffe's contention that differences in appearance of cracks may be due to longer time required for caustic cracking as compared with hydrogen embrittlement,

[1] "Boiler Embrittlement," by C. A. Zapffe, Trans. A.S.M.E., vol. 66, 1944, pp. 81–126.

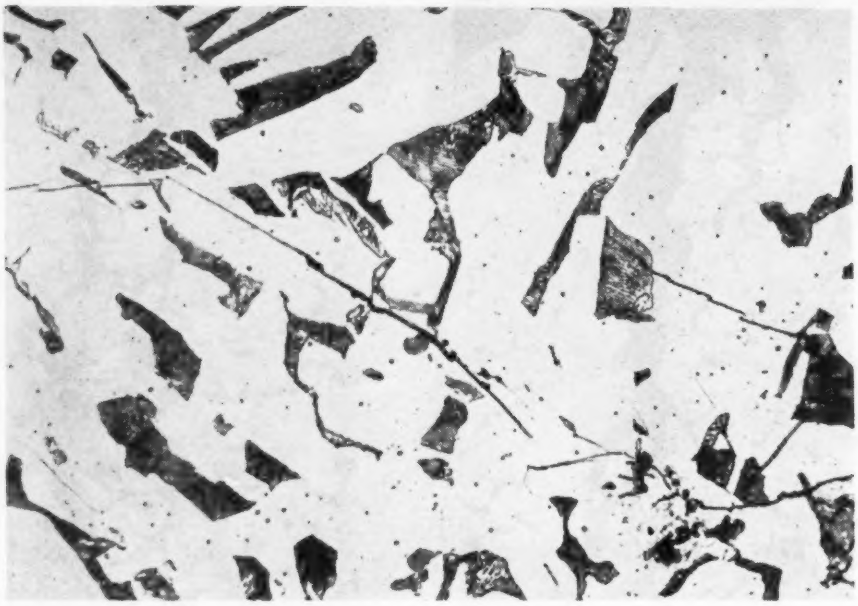


FIG. 12 TRANSCRYSTALLINE CRACKS IN HEADER PLATE, POSSIBLY REPRESENTING LOW-TEMPERATURE HYDROGEN EMBRITTLEMENT; ×500

caustic cracking produced by experimental methods is quite rapid, but shows all of the fundamental characteristics of caustic service cracks.

3 Hydrogen embrittlement combines cracking and brittleness. No brittleness of the steel has ever been established next to caustic cracks.

4 Caustic cracking, contrary to hydrogen embrittlement, does not involve decarburization of the steel.

5(*a*) Hydrogen embrittlement causes cracks by penetration of atomic hydrogen into steel and by chemical reaction of this hydrogen with the carbon, or impurities, to form gases which, unable to escape, develop pressures which finally disrupt the steel. The cracks, accordingly, originate at a distance from the surface and, when intercrystalline, follow roughly the direction of impurities and location of carbides, without relation to the direction of stresses. They are intermittent.

(*b*) Caustic cracks start at the surface and are continuous (though not always on the plane of one section through a specimen). In addition to the major cracks, short incipient cracks often are found at many points of the surface. The cracks are substantially in the direction dictated by the stresses, as modified by local conditions at any one point.

The listing of some of the differences between caustic cracking and hydrogen embrittlement is not intended to imply that hydrogen may have no part at all in the deterioration of boiler parts, but merely that the two types of cracking or embrittlement are not alike. The exact mechanism of the corrosion in caustic cracking is not well known. It seems certain, however, that the cracking does not involve the combined chemical-mechanical action of hydrogen and the evolved gases active in hydrogen embrittlement.

A type of transcrystalline cracking occasionally found in boiler steel, and shown in Fig. 12, may represent hydrogen embrittlement at low temperatures. It is not known to have caused actual failures.

HIGH-PRESSURE-TUBE EMBRITTLEMENT

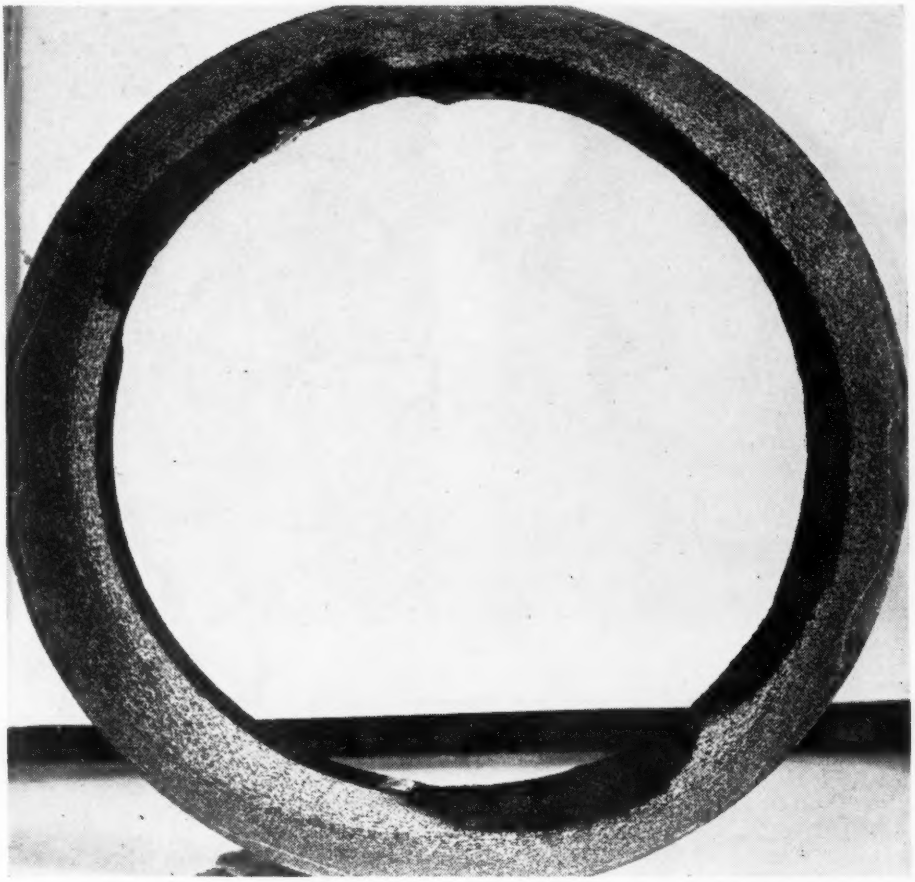
A type of cracking, possibly associated with embrittlement, not formerly known, has been experienced in recent years in waterwall and generating tubes of a few boilers operating at high pressures. In the absence of published data on this embrittlement, an examination has been made of two separate cases and has shown the characteristics of this type of deterioration to resemble closely the hydrogen embrittlement described, for instance, in the paper by Dr. Zapffe.[1] A comparison of the photomicrographs shown of this condition with those presented by Dr. Zapffe is of interest.

Much importance has been attached by some investigators to the presence of copper in this tube deterioration. Copper has been found on tube walls, in scale, and even in cracks near the inner surface. One of the specimens examined by the author, however, did not show any metallic copper, and less copper oxides, in the scale next to the deteriorated steel, than has been found in many boilers not affected by this trouble. It is believed that copper may play a part in this action and may affect some characteristics, but that it is not absolutely essential to cause the deterioration.

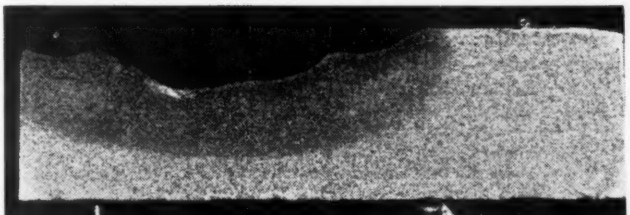
The embrittlement, in all cases known, occurred underneath a layer of hard, dense, magnetic iron oxide. Such oxide is known to form even in the absence of oxygen, on water-contacted tube surfaces at a temperature somewhat higher than expected in a boiler-tube wall under normal conditions and suggests moderate overheating due possibly to sluggish circulation. Although this interpretation appears to be more solidly founded on past experience, there is a possibility, not yet explored experimentally, that electrolytic action between copper and steel may, at the high temperatures involved, result in or contribute to the formation of an iron-oxide scale such as found. Following the hydrogen-embrittlement theory, it seems that continuing corrosion underneath an iron-oxide scale may develop nascent hydrogen part of which may not be removed by the circulating water-and-steam mixture and may then penetrate into the steel.

On visual inspection the steel appears entirely sound and normal. However, deep-etching of cross sections of affected tubes darkens the deteriorated steel. Metallographic examination shows features substantially in accord with those of steel attacked by hydrogen as shown in the literature. Differences in details may be accounted for by the limited quantities of hydrogen available and the relatively low pressures in boiler tubes. Typical photomicrographs of the features are shown in Figs. 13 to 18, inclusive.

According to investigations made elsewhere, atomic hydrogen penetrating into steel, at the temperatures involved, enters into solution with the steel, thus embrittling it at least temporarily, decarburizes the carbides, and forms, with carbon



(b)



(a)

FIG. 13 BOILER TUBES SHOWING ZONES OF EMBRITTLEMENT AT INNER SURFACE
(a, Longitudinal section; $\times 1^3/_4$. b, Transverse section; $\times 1^1/_4$.)

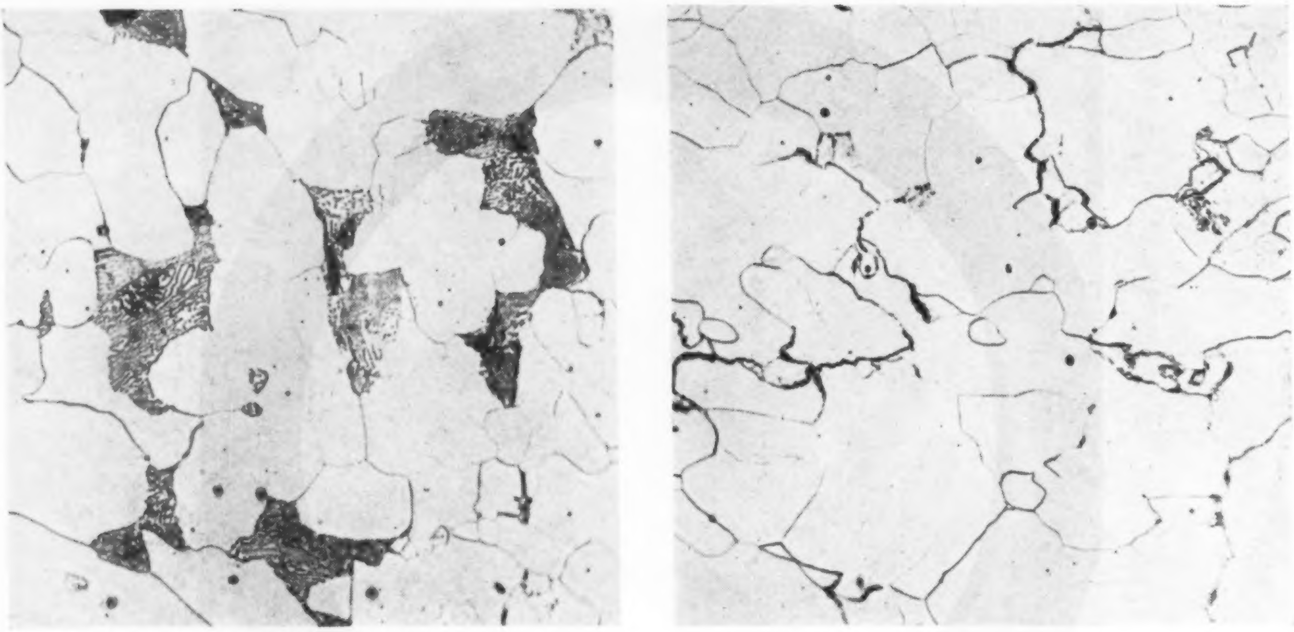
and possibly impurities, gases not soluble in steel and accumulating at grain boundaries until the pressures become excessive and burst the steel in intercrystalline cracks.[1] Of these effects, decarburization and cracks can be detected by metallographic examination.

All of the photomicrographs apply to the tube shown in Fig. 13(b). The characteristics of the tube shown in Fig. 13(a) were similar, but less clearly shown by photographs. The difference in characteristics between the sound and the deteriorated steel is shown clearly in Fig. 14.

The attack is progressive, with hydrogen passing through steel deprived of carbon into vulnerable areas. The attack on the still sound steel takes different forms. In some cases, cracks were found after hardly any noticeable decarburization. Other transition areas show decarburization without cracking; the majority a combination of decarburization and intercrystalline cracks. In accordance with the nature of this type of attack, the cracks are discontinuous, are not related to the direction of stresses, and are not connected to the surface since they are formed by the building up of pressures in confined gases. In many cases, the hydrogen first dissolves the thin layers or minute particles of carbide in pearlitic areas, sometimes leaving more massive carbides, with a lower ratio of surface to mass, in a pattern suggesting spheroidization of the steel, Fig. 15(a). The removal of the finer carbide particles appears to be quite rapid since the transition zone from fully pearlitic to apparently fully "spheroidal" structure often is less than 0.005 in. wide.

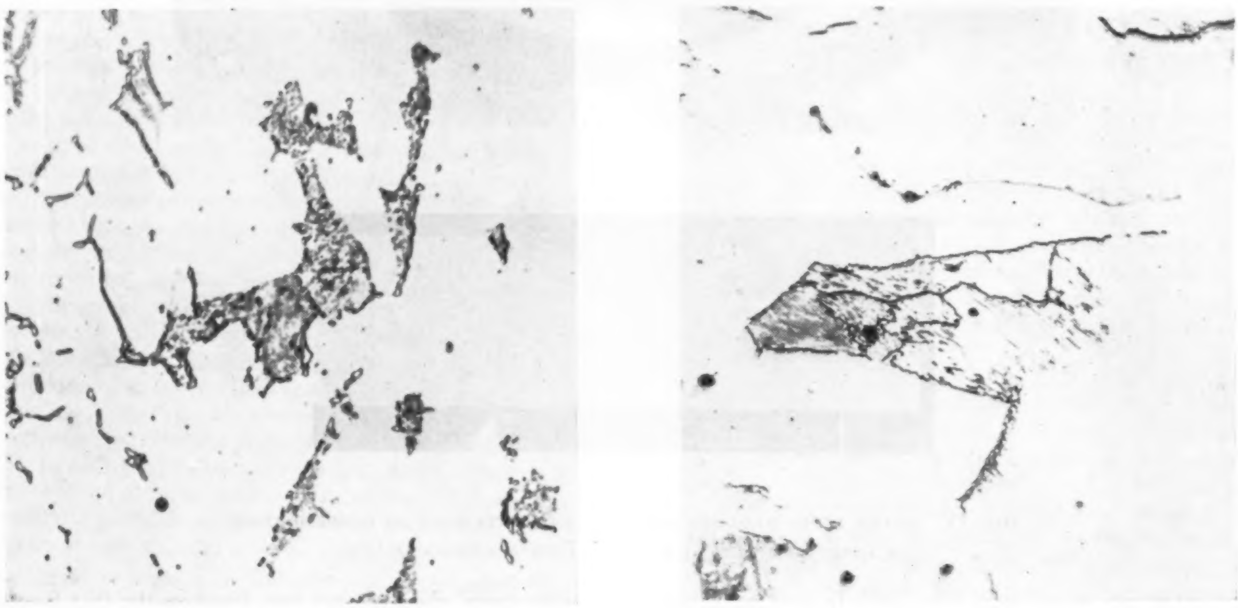
Fig. 15(b) shows a single pearlite grain in dissolution. A combination of decarburization and cracking, with complete removal of carbon from the areas next to the cracks, is shown in Fig. 16. Cracks in practically decarburized areas are shown in Fig. 17. The distinction between ridges of residual carbides and cracks is often difficult, and both microfeatures are represented in Fig. 18(a), with Fig. 18(b) showing a less advanced stage with definitely identified carbides.

This type of failure is particularly vicious because it involves a progressive deterioration of the steel by embrittlement, decarburization, and cracking, without development of pits or continuous cracks which, by leaking, might give a warning of impending failure. The latter may assume, and has done so,



(*a*) Sound steel (*b*) Deteriorated steel

FIG. 14 STRUCTURES OF SOUND AND DETERIORATED STEEL OF BOILER TUBE; ×1000



(*a*) ×750 (*b*) ×1200

FIG. 15 EMBRITTLED BOILER TUBE: VARIOUS GRAINS IN PROCESS OF DECARBURIZATION WITHOUT CRACKING

the form of a sudden tearing out of a large piece of embrittled steel in an explosive manner. The only precaution now appearing possible is a careful examination of scale removed from tubes during cleaning, provided that satisfactory methods for removal of the type of scale involved can be developed. The iron-oxide scale is not readily removed mechanically. Though chemical cleaning methods caused scale to come off in flakes from a sample of tubing, the effect of such cleaning on scale of a complete tube is not yet known and is in doubt in view of its apparent density and imperviousness. Combined chemical and mechanical cleaning may be a possibility.

An estimate of the frequency with which this type of trouble may occur is at present impossible. Although it has been identified so far in only three or four plants, its characteristics make it possible for it to remain present for a long time, and undetected, until it causes an actual failure. The lowest pressure at which it is known to have occurred has been 1200 psi. If iron-oxide scale is formed entirely by action between water and tube steel, boiler-tube-metal temperature would be the decisive factor.

The large field potentially opened by this suggestion is restricted considerably by the requirement of a probably narrow range of tube temperatures in which the dense, hard, adherent, iron-oxide scale will form. Since this temperature must be maintained for an extended period of time, favorable conditions are likely to develop only where circulation is sluggish, but sufficient to prohibit excessive temperatures at which a porous loose oxide scale or quick corrosion develop and cause a more rapid but less critical type of failure, or where an unusually high percentage of steam in the circulating fluid results in elevated metal temperatures. This requirement again is likely

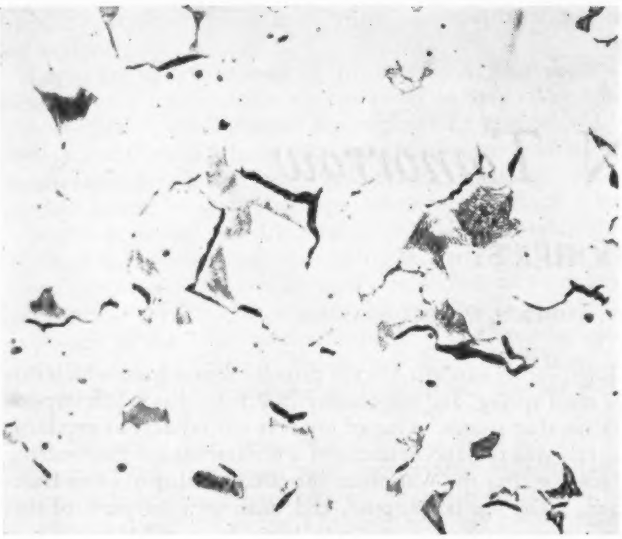
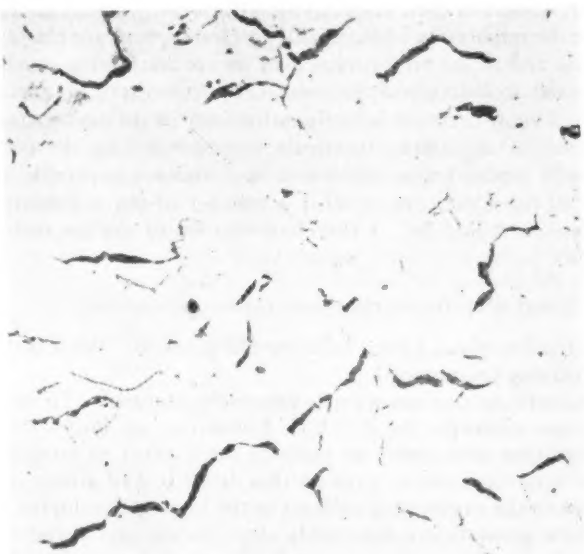


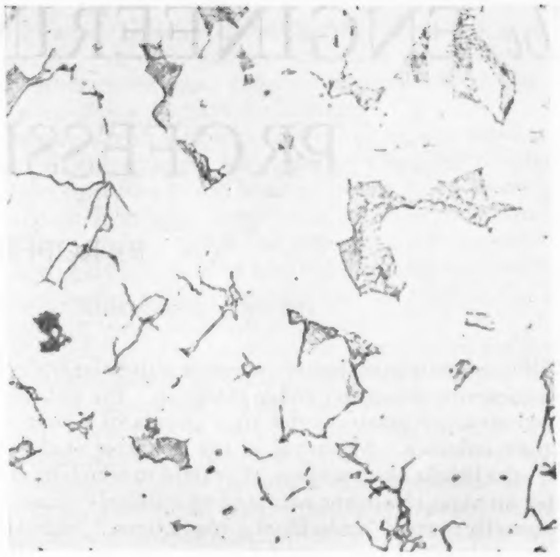
FIG. 16 EMBRITTLED BOILER TUBE; DECARBURIZATION AND CRACKING; ×500



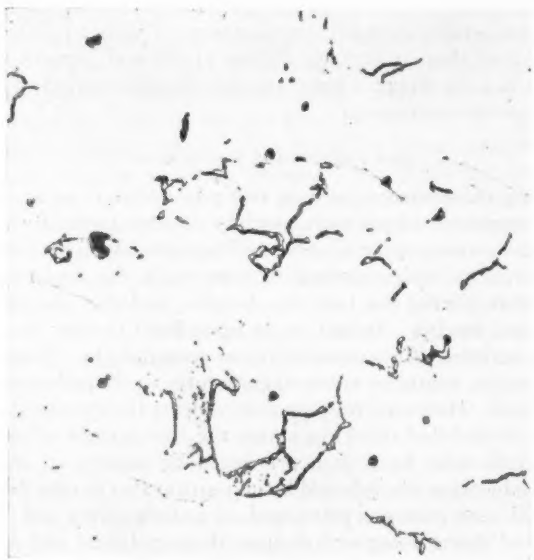
(a) ×500

(b) ×1200

FIG. 17 EMBRITTLED BOILER TUBE; CRACKS IN DECARBURIZED STEEL



(a) ×500



(b) ×1000

FIG. 18 CRACKS AND RESIDUAL CARBIDES IN EMBRITTLED BOILER TUBE

to be fulfilled only in high-pressure boilers in which the dangerous temperature range, which probably starts in the neighborhood of 800 F, or a little lower, is not much above normal tube temperatures. On the other hand, the field of potential failures would be broadened considerably if copper should be found capable of developing, or of contributing to development of, the hard iron-oxide scale at normal high-pressure-boiler tube temperatures.

ACKNOWLEDGMENTS

The author wishes to acknowledge the assistance of Mr. F. W. Brockman who did the metallographic work in the examination of many of the specimens referred to in this paper. The investigation of the high-pressure tube embrittlement was made possible by the kindness of Mr. E. H. Mitsch, of the Cincinnati Gas and Electric Company, Mr. A. R. Parker, of the Columbia Engineering Corporation, and Mr. R. D. Gillespie, of the Dayton Power and Light Company, who made samples of tubes available for examination.

The ENGINEERING PROFESSION *Tomorrow*

By ROBERT E. DOHERTY

PRESIDENT, CARNEGIE INSTITUTE OF TECHNOLOGY, PITTSBURGH, PA. FELLOW A.S.M.E.

THE engineering profession tomorrow will be largely what engineering education today makes it. The policies of industry, government, and state boards of course will have their influence. Nevertheless, the character of the profession—the height of its purpose, the extent to which its members live up to its ideals, the nature of its standards—must rest fundamentally upon individual convictions, individual attitudes, individual intellectual power; and these qualities are largely molded in college. The form of the mold is determined by the teachers and administrative officers of engineering colleges. If the profession is to be brought to the level which America needs, and is to receive the recognition which it deserves, the educators must bring it there. This is a pointed responsibility that, in light of lessons of the war, weighs upon us as it has not weighed upon any previous generation; it is a challenge we must accept.

WAR LESSONS FOR ENGINEERS

Among these lessons, at least two point directly at us. One is that engineers, along with members of other professions and American citizens generally, were altogether unprepared either by interest or understanding to cope with the fundamental issues that, during the last two decades, underlay the emerging global conflict. Indeed, right up to Pearl Harbor, we as a people were incredibly unaware of our actual plight. Once war was upon us, engineers arose magnificently to the technical job it imposed. However, they are contributing little to the clarification of muddled thinking about the foundations of peace. As citizens who have been privileged by society to receive higher education, they should be in position also to take a leading hand with others so privileged, in understanding and clarifying and determining action upon those political and social issues on which the future peace, freedom, and prosperity of the country depend.

The second lesson of the war is that the engineering profession found itself near complete paralysis when there was need for unified action on matters of common concern in connection with the war effort. As a member of the Engineers' Council for Professional Development for six years, during the last three of which I was chairman, I had firsthand experience in this matter. The problem was of course not new. The practical inability of the several branches of the profession to act in a common cause is traditional; merely the fact that they could not effectively unite for common action in war indicates the depth of the malady. Their tradition of isolation is understandable in light of the history of the successive beginnings and independent growth of the several branches of the profession. But the world moves on; change is inevitable, even in the engineering profession. While I make no predictions as to the specific nature of the evolution of the profession, especially of its organization, I do venture to predict that there will be—must be—change in point of view. The engineering profession must rise to a new level. That is our lesson from the war.

Engineering education is the primary source from which this rise must spring, and the Society [S.P.E.E.] has taken steps to vitalize that source. One of my first official acts as president last fall was the appointment of a Committee on Engineering Education after the War under the chairmanship of Dean Hammond. The spirit, purpose, and unanimity of view of this large representative committee have been most gratifying, and its report[1] merits wide interest of the engineering profession.

Members of the Society have been solicited to implement the report at once in their respective institutions. I regard as very great the importance of establishing a clearer picture of the profession and of the professional man we are attempting to educate, and accordingly of the general requirements of his education. I know there can be little enthusiasm for the fundamental revision of engineering curricula recommended in the committee's report unless there is a new vision comparable to that of the committee of what a member of the engineering profession should be. I therefore venture to outline such a picture.

WHAT CONSTITUTES THE ENGINEERING PROFESSION?

In the first place, I must raise the old question, "What is the engineering profession?"

Thought on this question is extremely confused. To mention one evidence, the E.C.P.D. Committee on Professional Recognition after some ten years of futile effort to establish criteria of recognition, gave up this direct line of attack and turned to the engineering colleges in the hope of developing in the new generation a reasonably clear professional purpose—a professional consciousness and like-mindedness—that the present generation of engineers does not have. Engineers are objective and clearheaded on their work, but when it comes to defining their field, their professional relationships, their specific eduational programs, this distinguished quality seems to vanish!

The two primary reasons for the confusion need hardly be reiterated. The first is that engineering graduates have entered many fields beyond those directly related to their engineering studies, for example, general management in business and industry, commercial work, accounting, and so on ad lib. We are all familiar with the ill-advised view that since engineering training has made success possible in these fields, they should be regarded as engineering when pursued by engineers. I could recommend as a hobby of rich possibilities the collection of adjectives now associated with the word "engineering!" This loose thinking confuses what an engineering graduate may do with what engineering is.

The other primary reason for confusion is the no-man's land between professional and subprofessional activity. There is no line of demarcation. And the confusion, already bad enough, has been greatly increased during the war. A high-school graduate learns in an ESMWT course how to carry out a

Presidential Address presented at the Fifty-Second Annual Meeting of the Society for the Promotion of Engineering Education, Cincinnati, Ohio, June 23, 1944.

[1] "Report of Committee on Engineering Education After the War," *S.P.E.E. Journal*, vol. 34, May, 1944, pp. 589–614.

specific routine of test or calculation, and ipso facto becomes an engineer!

Let us try to clarify some of this confusion. Are there any firm grounds upon which we can stand in indicating what, fundamentally, distinguishes the engineering profession from others and from the body of nonprofessional technicians? I think there are, but before I undertake a suggestion, let me confess to one of our handicaps. A struggle which I have myself experienced and discerned in others is trying to think through this problem without being bedeviled by such questions as how one's ideas if adopted would affect membership in engineering societies, or engineering enrollment, or the importance of one's particular course. I believe, however, that we can be realistic about such practical matters and yet proceed with a clear purpose; I am certain that we should do so.

In beginning such procedure, we must draw some general boundary lines. I certainly would not lay undue emphasis upon a legalistic approach, but there are a few simple criteria for a professional group that are, I believe, essential for our purpose and also rather widely acceptable.

They are as follows:

1 That its members shall have acquired an organized body of higher learning.

2 That they serve their clientele by the application of that learning.

3 That they control a system of professional education and strive continually for its improvement.

4 That they share a common purpose and method of service and a common code of conduct with respect to each other and to their clientele.

Then I would add a fifth:

5 That they serve their country by expert counsel in their field by participating as civic leaders in community enterprises, and by forming intelligent judgments on political issues and then actively supporting them.

I believe these points are not inconsistent with the thoughtful pronouncements by President Wickenden[2] and Dr. Bush,[3] who are engineers, by Abraham Flexner,[4] a student of higher education, and more recently by Dr. Robert S. Lynd,[5] professor of Sociology at Columbia University.

To these five criteria for professions in general, we must add one that will identify the profession of engineering. I realize that at this point we enter highly controversial grounds. After studying numerous definitions in which attempts have been made, for one purpose or another, to bound the field of engineering, I would suggest the following modification as both essential and sufficient for our purpose:

Engineering is the art, based primarily upon training in mathematics and the physical sciences, of utilizing economically the forces and materials of Nature for the benefit of man.

This definition will be criticized as too narrow; it should include organizing and managing men, social responsibilities, etc. But remember, other people and other professions as well as engineers have responsibilities in these areas. We are not trying to state everything a member of the engineering profession may conceivably do; we are trying rather to suggest broadly those things that distinguish him from other professional men. For our purpose we need do no more, but if we are to get anywhere with our present task we must do at least that.

[2] "The Second Mile," by W. E. Wickenden, *Electrical Engineering*, vol. 61, May, 1942, pp. 242–247; also abstract, MECHANICAL ENGINEERING, vol. 63, 1941, pp. 297–299.

[3] "The Engineer and His Relations to Government," by Vannevar Bush, *Electrical Engineering*, vol. 56, Aug., 1937, pp. 928–936; also abstract, MECHANICAL ENGINEERING, vol. 59, 1937, pp. 615–646.

[4] "Universities," Oxford Press, New York, N. Y., 1930, pp. 29–31.

[5] *The New York Times*, March 18, 1944.

NONPROFESSIONAL ACTIVITIES OF ENGINEERS

If we accept these six criteria for the engineering profession, we are in position to be more specific as to its differentiation from other professional and quasi-professional groups whose work touches or overlaps engineering.

Consider a few examples. Take the engineer, a member of the engineering profession, who manages a business or a large industrial enterprise at top level where the functions are general management, or who runs a bank, or accounting firm. Is he practicing engineering? Is the lawyer who does the same things practicing law? I think we need not labor that question further. The engineer is still an engineer, the lawyer is still a lawyer, but neither is practicing his profession.

What, then, is he practicing? It may or may not be a profession. It is if it meets the criteria—a body of higher learning, a common purpose and method, a common code. For example, there is unquestionably an emerging profession of business and industrial administration, but it has not yet arrived. Indeed, its development seems far behind that of engineering. Meantime those professional people like lawyers and engineers whose fields and methods are related to some of the basic requirements of professional management have found satisfaction and success in these management fields. A professional engineer in such management is practicing a quasi-profession, but it is not engineering. Let me repeat: We must not confuse what an engineer happens to do with what engineering is. This point has fundamental significance when we are considering engineering education. We should not, I venture to suggest, sacrifice essentials in engineering education for courses in general management, and thus have neither fish nor fowl.

The engineer's particular qualification for management is his method—the engineering method. But the engineer has no monopoly on that method—the method of a carefully calculated plan based upon principle and fact. It comes near to being mere professional common sense. Certainly one finds scientists, physicians, and businessmen who use it. However, it deserves the name, because the engineer has demonstrated its power; he has always used it; he has become its symbol. And therefore wherever, as in management, such a straightforward rational approach is effective, those engineers who in their stride can learn the necessary new subject matters outside engineering become successful.

However, there is a kind of management that is engineering. It is, obviously enough, the management of engineering operations, involving the engineering executive whose decisions rest upon the professional qualifications we have defined—decisions, in other words, that a lawyer or businessman is not competent to make. Included in such management is the supervision of industrial production. Passing judgment upon the specification, design, and cost of machine tools together with other aspects of a production plan, and controlling the flow of materials and products, certainly fall within the scope of engineering as we have defined it, just as does the making of such a plan. Engineering education should therefore recognize such management as engineering.

Turning from such distinctions at the professional level to the boundary between professional and subprofessional levels, we may, I think, draw this important line of demarcation by two ideas. One has already been mentioned, i.e., that the members of the profession must have acquired "an organized body of higher learning." This, I take it, means educational progress at least up to the level of the baccalaureate degree. The second idea is that the engineer's work is characterized largely by rational processes, whereas subprofessional work is characterized largely by rule-of-thumb methods. These distinctions are educationally most important.

All of these boundary lines and distinctions are intended to afford a basis for outlining an adequate picture of a member of our profession, and thus for outlining what his education should be.

In that picture I see an educated man who can take his place in the community among members of other learned professions; who has mastered the essential "body of higher learning" that underlies his profession, including a live knowledge, sufficient for good citizenship, of the world in which he lives; who has learned to think critically and constructively in terms of that knowledge; who has mastered the engineering method; who has cultivated to the utmost his creative talents; who has a professional consciousness and lives by it; who has traveled "The Second Mile;" and who plays the part of a leader in civic affairs. That is the kind of man we should visualize when we are planning engineering education after the war.

PLANNING THE EDUCATIONAL PROGRAM FOR ENGINEERS

Needless to say, one would scarcely hope to see all engineering graduates achieve such full stature any more than the medical profession can hope to see all of its members achieve top stature; but I am nevertheless proposing that engineering education should set as its main task the planning of programs whose purpose would be to cultivate such professional men and therefore such a profession. Those who would achieve something less than such a full stature would yet be professional men whose education had at least laid the right kind of foundation.

If we accept the picture here outlined, we are in position to indicate the primary requirements with respect to which any program in engineering education should be tested. In the first place, has the "body of higher learning" been clearly defined and does the program lead toward its mastery? Secondly, is the "engineering method" in its broad sense clearly formulated and its cultivation carefully planned for in all phases of the program? And finally, are there definite provisions for developing a "professional consciousness?" My purpose is certainly not to write the answers to these questions, for I believe they are appropriately answered in broad outline in the Report of Dean Hammond's committee.[1] I wish merely to indicate a few personal opinions regarding them.

The stumbling block is the "body of higher learning." I wish that some wise providence might cleanse our souls when we sit as designers of educational programs. Why, if our purpose is the cultivation of an intellect, do we feel under such irresistible compulsion to clutter the student's mind with an impossible tonnage of inert undigested subject matters? We tend to include everything to the limit only of the student's time and endurance, and certainly at the cost of unfortunate sacrifices in thorough understanding and in the art of constructive use of the knowledge he does acquire. I wish to submit a practical suggestion as to how subject matters may be intelligently limited.

It is to define specifically the essential body of technological learning underlying the branch of engineering concerned. As tests for defining it, I would suggest three criteria:

1 It should include the fundamental ideas, principles, and basic facts underlying the field and be limited largely to these and to materials involving their direct application.

2 It should be limited to what can be thoroughly understood.

3 It should be limited largely to what will be used later by the student in a planned curriculum, or in postgraduate or postcollege study.

A similar procedure is of course also called for on the humanistic-social side.

CULTIVATING INTELLECTUAL POWER

Then I wish to submit a thought or two regarding the cultivation of method. This is educationally the crux. Intellectual power, not merely routine skills and memorized facts, is the primary end. Acquisition of subject matter without a cultivated intellectual method of applying it to practical situations is educational sterility. Such method and power are characterized by efficient intellectual approach, by the ability to relate ideas to situations.

A few components are as follows:

(*a*) Resourcefulness in identifying relevant data, in distinguishing the important from the trivial.

(*b*) Ability to analyze a practical situation in terms of principle and to draw rational inference.

(*c*) Resourcefulness in inventing means to an end.

(*d*) Capacity to distinguish between a verified generalization and a doctrine or policy, between fact and opinion.

(*e*) Habit of thorough understanding.

(*f*) Capacity for making value judgments.

(*g*) Ability to organize thought, to relate ideas logically, and to express them well in writing or speech.

These qualities do not appear spontaneously; they must be cultivated. The colossal and tragic blunder in education today takes rise from the fallacious assumption that a mind crammed full of subject matter will automatically become a cultivated intellect. One sees at the low end of the scale in educational procedure an instructor pouring out words to passive students; at the high end, the students taking the active part under the guidance of an instructor who realizes that the student's business is to learn to understand and think and do according to a carefully constructed educational plan thoroughly understood by the instructor. Any curriculum or individual component of it that is planned without primary emphasis on the cultivation of the powers and qualities just mentioned represents a vital sacrifice imposed upon the student in the interest—of what? I can think of only one thing: the outmoded educational tradition of yesterday.

Let me urge with all the force I can a shift in emphasis in educational planning from subject matter to intellectual method, from cramming to constructive thought, from the talking instructor to the active student. Let us plan to cultivate precious intellectual qualities and thus give the students what they have the right to receive.

CONCLUSION

My purpose here has been to focus the attention upon our inescapable responsibility—the cultivation of a renaissance in the engineering profession. I have tried to show that the profession must rise to a new level, must become more closely knit, and that engineering education must bring it to this new estate. But this undertaking is hopeless unless we are much clearer on what should constitute the engineering profession, unless we have a correspondingly clearer picture of what the individual member of the profession should be and therefore of the kind of education that will produce him. We cannot develop such a profession and still continue to regard engineering as everything an engineer may do and to gloss over civic responsibilities. Hence I have suggested boundary lines for the profession, tried to establish a picture of the ideal professional engineer, and to outline his educational requirements.

The Report of the Committee on Engineering Education after the War[1] points the way in education, and the co-operation of the E.C.P.D. and S.P.E.E. committees according to a definite plan approved by both bodies affords the means for developing professional interest and understanding. Moreover, the E.C.P.D. Committee on Canons of Ethics is, after years of patient study, struggling toward a formulation acceptable to the whole profession. So the profession is trying to be reborn. I hope that we, as engineering educators, shall accept the opportunity now before us to take the lead in professional education, and lay the foundation for a genuine engineering profession that must, sooner or later, inevitably come, and that would contribute significantly to a prosperous and secure America.

RAILWAY EQUIPMENT

Effect of the War on Development Work and Postwar Materials

By E. D. CAMPBELL

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SPECULATION in the press and elsewhere on postwar developments has unquestionably led to erroneous conclusions concerning new types of materials which will be available, and their possible applications. The four materials most widely publicized are alloy steels, aluminum, magnesium, and plastics. The purpose of the present paper is to indicate the potential uses of such materials in connection with the construction of railroad equipment.

CHARACTERISTICS OF AVAILABLE METALS

Weight. In weight we find that steel in pounds per cubic inch is 0.285, aluminum 0.101, magnesium 0.065. Thus steel is approximately 2.8 times heavier than aluminum, and 4.4 times heavier than magnesium. This weight ratio is of course the appeal in any analysis of metals. In design, however, we must know the strength values of the materials.

Strength. In any strength analysis, we are first interested in the yield point of the material and its ultimate strength. A rough comparison of these values of the different materials, again compared to steel, is given in Table 1.

TABLE 1 STRENGTH COMPARISON OF METALS

	Yield point, psi	Ultimate strength, psi
Carbon steel 1020	32000	60000
Alloy steel (Cor-ten)	50000	70000
(Republic double strength)	55000–70000	70000–90000
Aluminum alloy (17S-T)	37000	60000
Aluminum alloy (24S-T)	50000	68000
Magnesium alloy (Am-E-57)	26000	37000 – 45000
Stainless steel (18-8 CR)	50000–150000	100000–180000

In the materials listed in Table 1, the physical characteristics vary according to elements included and subsequent treatment given the material.

Modulus of Elasticity. Another strength ratio vital in computing strength of car members, is that of the modulus of elasticity. In this characteristic, we find that steel is 29,000,000 psi; aluminum 10,300,000 psi; and magnesium 6,500,000 psi. In cold-rolling stainless steel, the modulus of elasticity may be brought down to a low of 21,000,000 psi.

As E is one of the denominators in deflection formulas for beams, it is readily noticeable that this value has a direct ratio to the amount of deflection of the beam or member under consideration. From this analysis of strength characteristics, which is only representative, it may be assumed that any one or all of these materials can be used in car construction.

Probably it should be stated here that neither aluminum nor magnesium has any practicable value as structural members until the base metal is alloyed and heat-treated; therefore the resultant physical characteristics are dependent upon the kind of alloys used and heat-treatment given.

Other Properties. However, other properties and costs enter the picture. The matter of ductility is a serious one in connection with some members of a car. It might also be mentioned that some alloys tend to become brittle at extremely low temperatures. Probably the one given the most serious consideration by a prospective buyer of equipment is that of cost. Here again, we can become oriented as to the comparison of costs by using carbon steel as the base. At present, plates and shapes of carbon steel are $2.10 cwt base, Pittsburgh, or a base of 2.1 cents per lb. Alloys of steel vary in cost, of course, as to the kind of alloys used. Probably the least expensive is Cor-ten. This alloy at present costs 3.25 cents base, plus freight. The aluminum alloy will probably sell for 24 cents per lb, plus freight. Stainless steel may cost about 34 cents per lb. Plastics cannot be at all fixed as to price, inasmuch as so many different kinds are manufactured, and the quantity involved contributes largely to the ultimate cost. As a guess, and for comparative purposes only, we might say that plastics will cost anywhere from 45 cents to a dolllar per lb.

Just from a cost standpoint the obvious deduction is that the low-priced alloy steels have an advantage.

The other factors are cost of maintenance and ultimate life of the equipment using the foregoing materials. The answers to these factors can be as varied as the so-called authorities who are questioned, and this is understandable inasmuch as the answers hinge upon the conditions under which the equipment operates.

Without looking into such variable fields as maintenance and ultimate life, the author will confine his observations to the record.

MATERIALS FOR 1944

At a conference called by the Association of American Railroads, on December 14, 1943, which meeting included representatives of all the large steel companies and the aluminum industry, it was stated to the carbuilders present that, for the year 1944, the carbuilders could only consider those materials with which we were familiar before we entered the war. This conference also fixed the designs of freight cars which the W.P.B. is sanctioning for construction during the year 1944. The record therefore discloses that 1944 will not unfold any new materials for car construction. This eliminates all materials for the structural members of freight cars except carbon steels, alloy steels, and aluminum alloys. The year 1945 may bring forth materials representing an advance in the physical characteristics for the benefit of the car-equipment industry. However, at the present time, due to military secrecy or other considerations, we have not become acquainted with such materials.

Magnesium. Magnesium does not occur in nature as a metal but as an ore, in combination with other elements known as magnesite, of which there were large deposits in Michigan. Owing to the vast demands of the war, these deposits were becoming so badly depleted that it became necessary to develop facilities for the production of magnesium from another known and unlimited source, namely, sea water.

The electrolytic method is the most widely used method of producing magnesium from magnesite and, in the case of sea water as a source, a preliminary processing is necessary to get it to a state corresponding to magnesite.

The outstanding property of magnesium is of course its lightness, being two thirds of the weight of aluminum. In order to be used structurally, like aluminum, it must be alloyed

Presented at a joint meeting of the Hazelton-Pottsville Districts, Anthracite-Lehigh Valley Section of The American Society of Mechanical Engineers, Berwick, Pa., January 28, 1944.

and heat-treated. It surpasses aluminum in machinability and can be cast, forged, or extruded as easily as aluminum. It can be formed into sheets and plates but not as readily as aluminum. While from a weight-strength ratio it surpasses aluminum, its deflection is about twice that of aluminum, thus nullifying some of its weight-strength advantages where deflection is a factor to be considered.

Magnesium corrodes readily due to its affinity for oxygen and nitrogen, so it must be primed or painted to protect it from contact with moisture. It is not desirable for use where it comes in contact with excessive moisture or salt water. It has a bright silvery luster which quickly darkens by oxidation. So far no method has been perfected to anodize magnesium, like aluminum, to preserve its luster and prevent oxidization.

It has a definite fire hazard in such forms as dust or chips which puts it at a disadvantage with aluminum.

Magnesium has not been so well known in the past and was not used extensively before the present war. Due to its lightness it has found many applications in aircraft.

With the vast facilities which have been developed to produce magnesium, its cost, which has in the past been high, will naturally approach that of aluminum and open up many other fields for application in the automotive and industrial fields, as well as aircraft. It will have a place in passenger-car construction in interior trimming, fittings, and hardware, where strength and appearance are not an important factor.

As previously stated, not a great deal is known about magnesium in service. It has proved satisfactory in aircraft-engine and fuselage construction and also very satisfactory where used industrially.

Undoubtedly much has been learned during the war about the production and behavior of magnesium, which is a military secret, but when this information is released it will probably open up unknown fields for application.

Plastics. Plastics are never found in nature, but are man-made and, therefore, synthetic, materials. The plastics field is very broad in its scope and there are about ten principal basic compounds. Among these can be picked materials possessing desirable characteristics of strength, toughness, surface hardness, colorability, and clarity. The same yardstick for measuring strength and hardness as used for metals does not apply for plastics, so careful selections for any requirement must be based upon experience.

Plastics do not possess the same strength as metals and so in this respect are not comparable with the lighter metals although they are in weight.

Plastics can be readily molded into any shape and this art is well developed. In the railroad field plastics will be limited to interior passenger-car construction, where appearance is a factor and not strength, such as hardware parts, trimmings, seat parts, window capping, table tops, and, in the fabric form, for upholstery.

The use of plastic resins has been developed for plywood construction and for bonding of wood or steel. In combination with paper, cloth, asbestos, and fiber, laminations have been developed which possess a much higher strength than plastics —micarta and formica being examples.

FREIGHT CARS—ASSOCIATION OF AMERICAN RAILROADS AND INTERSTATE COMMERCE COMMISSION

All freight cars must meet the specifications of the A.A.R. for design and the I.C.C. specifications for safety appliances. Any cars not meeting these specifications will not be accepted in interchange. Consequently, any radical changes in design must first be submitted to the A.A.R. This body may consent to try out the new idea in experimental service. This tryout may extend for a period of several months or for several years. If then approved it can be applied to cars for interchange with the different railroads. The necessity for this is understandable since the railroads must make sure that cars accepted for interchange (1) will stand the service; (2) can be easily repaired; (3) no hazard involved in their operation; (4) meet all I.C.C. requirements; (5) repair parts must be stocked so that cars can be kept running.

Progress. The impression might be gained that the railroads and the car-equipment industry are standing in the way of progress, but this is an erroneous idea. The facts are that the railroads through the A.A.R., and also by individual effort, and the car-equipment industry are all continually developing new ideas, and improvements for railroad cars. A fact which is generally overlooked by the public in connection with railroads is that they sell transportation and are not basically manufacturers.

In other words, they do not have a manufactured product to sell but are buyers of equipment with which to furnish transportation. Thus when people criticize railroads for lacking progressive ideas, they probably do not realize that developments in their rolling stock are first instigated by the equipment builders and then those improvements are subjected to research and service tests by the railroad before being adopted. This procedure is slow but sure. The splendid record of the railroads should be a final and adequate answer to such criticism.

The A.A.R. Car Construction Committee has for years followed a program which is based in part upon improving rolling stock. New demands for speed and carrying capacity have created new problems which were foreseen by the railroads and the equipment industry and, in so far as consistent, developments have been made to forestall defects. As an illustration, the A.A.R. has been conducting for the last several years a series of tests of freight-car trucks capable of sustained high speeds.

In the author's opinion, it is indeed fortunate that the railroads have adhered to the policy of approval of the A.A.R. before new ideas of equipment were placed in service; otherwise, it is feared that the magnificent job accomplished by them during this war could not have been possible.

Forecast. As a forecast of what we may expect in future freight cars, and calling attention to the fact that it is only the author's opinion, the following possibilities exist:

1 The conventional freight car will be several thousand pounds lighter than those in general use today.

2 Trucks will be utilized capable of speeds at least up to 80 mph without serious damage to ladings.

3 The use of steel alloys for the majority of strength members in freight cars will become common practice.

4 A limited number of cars, particularly those which because of lading are subject to severe deterioration by corrosion and oxidation, will be built of aluminum alloy.

PASSENGER CARS

The field of design for passenger cars is quite apart from that of freight-car design, as much more latitude is allowed in new ideas, and of course many more different kinds of materials are utilized.

Materials. Undoubtedly there is a place for all the materials previously mentioned in passenger cars. Here the element of cost is not so vital and the features stressed are light weight, comfort, riding qualities of the trucks, and travel conveniences of many kinds.

In design, however, discretion must be used since strength requirements for safety are mandatory. No carbuilder would ever design any passenger car not fully meeting the A.A.R. requirements for strength. Therefore, the main structural members of a passenger car are confined to the steels and the alloys of aluminum. The steel family includes carbon steels, alloy steels, stainless steels, and variations of these. Aluminum, as stated, can only be used for strength members when alloyed, and here the alloy must be selected with the required characteristics.

Interiors. The interior finish, which has no bearing on the strength of the car body, can be any one of many materials.

Here plastics will come into use for interior trim and fixtures. Aluminum will also play a prominent part, particularly since it is a factor in weight reduction. Plywood and plymetal with different compositions of wood have been and will continue to be used for doors, partitions, and other interior equipment.

Weight. Before this war, great strides were made in reduction in weight in passenger cars. Prior to the depression years, a conventional steel coach weighed as much as 160,000 lb. This same car of equal strength and dimensions, but with four-wheel trucks, by the use of steel alloys weighs 112,920 lb. A stainless-steel car of practically the same dimensions weighs 114,110 lb. An aluminum car of this type weighs 104,060 lb.

Weight reduction in passenger cars will probably not go below the present level. The carbuilders are now prepared to offer designs in carbon steel, alloy steel, and stainless steel, of welded or riveted construction. Practically all carbuilders building passenger cars can also offer a car built of aluminum alloys.

The passenger car is now fairly well standardized as to dimensions both in length and contour and, in the author's opinion, the designs were in an advanced stage proved by several years' service. It is therefore only in the comfort of riding that we can look for things to happen in the postwar period; foremost and fundamental in this respect is an easy-riding truck.

Truck. The six-wheel passenger truck seems to be a thing of the past, and the long-wheelbase four-wheel truck has succeeded it. Cars are now running with these four-wheel trucks and giving excellent riding qualities. However, all four-wheel trucks do not ride easily, and even the best designs ride roughly under certain track conditions and under any track conditions if not properly maintained.

Seats. Another necessity for comfortable riding is satisfactory seats. In discussing seats it should be made clear that seats for suburban and city traffic are quite different from the de luxe type of coach seat. This discussion applies only to the de luxe type passenger car in which the seats are spaced farther apart and comfort is desirable. Seats to be comfortable should have upholstery of very good depth, either spring cushion or sponge-rubber cushion, and for overnight travel have reclining backs.

Lights. The fluorescent light became quite popular for lighting cars but probably did not reach its full stage of development when passenger-car work was suspended. It is understood that lighting-equipment manufacturers are now prepared to offer this light with reasonable assurance that it will give satisfactory service. The de luxe type coach travel, it is believed, will demand two things in lighting; (1) General illumination of the car without any glare and without any bad effect on the eyes; (2) each individual in the car will have sufficient intensity of light at the reading plane so that he can read comfortably for long periods without any undue eye strain. The latter requirement probably means individual lights over each seat.

Air Conditioning. It is taken for granted that all de luxe travel equipment will be air-conditioned. In thinking of air conditioning one is so apt to consider cooling only. Air-conditioning engineers realize that conditioning the air means correct temperature for body comfort with proper relative humidity in the air under all conditions of outside weather. This idea of air conditioning has been completely developed and is in use in some cars. It is entirely automatic and will properly condition the air on the same trip in weather from zero to 100 F. This is the ideal system and will probably be generally adopted at some time in the future.

Sash. It is fairly evident that the public is not completely educated as to the necessity of having fixed sash in air-conditioned cars. This situation has been recognized by some railroads, and they provide for it by having one or two windows at each end of the car arranged to slide. The feeling regarding sash is due to breakdowns in the air-conditioning equipment during exceptionally hot weather, under which conditions the passengers feel depressed. It is believed, however, that air-conditioning equipment will be so designed and built that failures during trips will be practically eliminated. The sash in cars now have double panes of glass with the so-called breather arrangement whereby fogging and clouding does not occur between the glass due to differences between outside and inside temperatures. In fixed sash it is easy to obtain absolute tightness in fitting it into the car.

Coach Power Requirements. The demand for power for lighting, air-conditioning, and other appliances has reached such proportions that a 20-kw generator is the minimum generally used. The accepted practice is to hang the generator on the under-frame of the car and drive it through an attachment on one of the axles. Manifestly, this puts quite a load on the locomotive with trains having 16 to 18 cars. At the present time there is some agitation to have a self-contained power unit in each car. The source of power contemplated is a small Diesel directly connected to the generator.

Heating. Under the subject of air conditioning it was mentioned that the future systems will incorporate heating as well as cooling. At the present time, however, practically all cars are heated by an independent system of steam heat controlled through the air-conditioning switchboard. This system derives steam from the locomotive and is piped throughout the length of the train. Obviously a train length of 16 or 18 cars involves some problem of obtaining sufficient heat in the rear cars. This is largely overcome by stepping up the pressure and by regulation. Even so, 15 to 20 min are sometimes required after steam is turned on before the rear cars are sufficiently heated for comfort.

The all-weather system, predicted for the future, overcomes this difficulty by a different system of heat distribution. In the year-round air-conditioning system, the air is heated by being blown over heated fin-tube coils.

Decorative Treatment. The interior treatment of passenger cars seems to run in cycles between very plain and highly decorative finish. At the end of the passenger-car building period which was April 5, 1942, we reached the height of artistic treatment and were on the declining side of the cycle. Probably one reason for the highly decorative interiors, during the depression years of the 1930's was due to the desire on the part of the railroads to attract traffic away from the buses and private automobiles. At that time highly paid interior decorators were employed and rather lavish interior decorative schemes were used. Probably the economics may determine the extent of interior treatment and the author's guess is that, while we will have pleasing interiors, the lavish expenditure of money for artistic effect will pass out. However, the tremendous progress made in the development of materials which can be used in passenger-car interiors has been so great that we may see artistic use of these materials. Reference is made to the use of plastics, aluminum, stainless steel, and various resinous-wood combinations.

POPULAR TYPE OF CAR

For the last 7 or 8 years, a type of travel has become very popular for a single overnight run; that is, runs of, say, 16 to 26 hr, such as between New York and Chicago, and between the East Coast and Florida. These trains have as the major portion of their consist, the so-called sleeper coaches which are equipped with comfortable reclining seats. No extra fares or charges of any nature beyond that of coach travel are demanded by the railroads for such travel, and most people, if only spending one night on a train, prefer this means of reaching their destination. These cars are provided with sufficient toilet necessities for their passenger capacity and are made quite attractive in appearance. Anyone who has traveled between New York and Florida knows that seats on such trains must be reserved in advance.

Even though one is assured of up-to-date equipment, coach travel has two outstanding drawbacks. One is the lack of as-

surance of a seat, especially in these times, and the other is the bother of taking care of luggage. Here the railroads could profitably borrow some ideas from the air lines. If these two inconveniences could be eliminated, travel in modern coaches would be accelerated. It is possible to do these two things and, in fact, on a few trains it is now being accomplished. It is done by the railroads reserving a seat when the ticket is purchased, and providing means whereby baggage is stored in the car and not left to the passenger to take care of. Locker space at the ends of the car, guarded by the porter, takes care of the luggage.

PROBABLE POSTWAR CAR BUSINESS

All sorts of prophecies have been made as to the volume of new-car business for production after the war. There is no question but that a large volume of both freight and passenger cars will be ordered when the materials are available. The number, the author suspects, will be somewhat dependent upon the financial condition of the roads. Thousands of cars will be needed to replace obsolete equipment and cars now running which will be unfit for service.

The forecasts vary all the way from 25,000 freight cars per year up to 175,000. Any formula used to arrive at some conclusion based upon replacement due to worn-out equipment plus obsolescence, plus potential carloadings and also plus economic demand for light equipment, results in a tremendous number of freight cars necessary to be purchased each year for at least a 5-year period.

Other agencies employed in forecasting postwar activities use a formula based upon revenue-ton-miles of anticipated business. A conservative estimate is probably that at least 100,000 cars will be purchased each year for a 5-year period after the war, or longer.

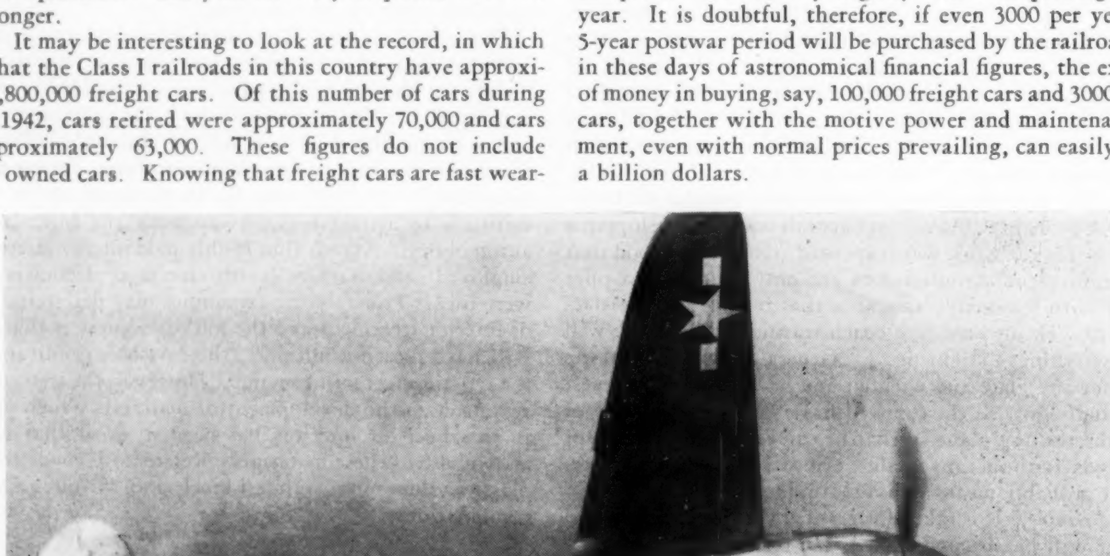
Record. It may be interesting to look at the record, in which we find that the Class I railroads in this country have approximately 1,800,000 freight cars. Of this number of cars during the year 1942, cars retired were approximately 70,000 and cars built approximately 63,000. These figures do not include privately owned cars. Knowing that freight cars are fast wearing out as a result of extensive use, it is not too optimistic to forecast that 100,000 new cars per year will probably be purchased.

The record of the totally owned cars by Class I railroads as of January 1, 1943, shows that 536,802 cars, or 30.8 per cent are over 25 years old, and only 142,138 cars, or 8.1 per cent, are under 10 years old. It requires no stretch of the imagination to realize that with more than 500,000 cars over 25 years old and still in use, the requirements for the first postwar 5 years could easily be 500,000 cars.

The forecast for new passenger cars likewise varies widely but the record is revealing and undoubtedly has a good basis for a guessing contest of the potential future passenger-car business.

The record as of January 1, 1943, shows that the Class I railroads in this country owned 38,050 passenger cars. Of these 19,175 cars, or 50.4 per cent were over 25 years old. Under 10 years, there were only 1441 cars, or 3.8 per cent. A passenger car over 25 years old, means that it was built before 1917, or before the first world war. Manifestly, such cars cannot be conceived as modern. Any prophecy, however, as to their replacement, in the author's opinion, cannot be based upon age only, inasmuch as many of these old cars can be used in short-haul and suburban service. However, railroads must equip their main-line trains with modern equipment of the last word if they expect to retain and acquire traffic.

A recent survey made by one of the largest industries in this country forecasts that 15,000 passenger cars of all types will be purchased in the postwar period. This forecast is not intended to imply that this number of cars will be built in the first year. As a matter of fact, the carbuilding capacity in this country at the present time is only slightly over 3000 passenger cars per year. It is doubtful, therefore, if even 3000 per year for the 5-year postwar period will be purchased by the railroads. Even in these days of astronomical financial figures, the expenditure of money in buying, say, 100,000 freight cars and 3000 passenger cars, together with the motive power and maintenance equipment, even with normal prices prevailing, can easily approach a billion dollars.



Lockheed Photo by Erik Miller

THE NEW P-38

(Carrying two Weber-built drop tanks, twelfth improved-model *Lightning*, this new superrange fighter, P-38, is 30 per cent more powerful and has 30 per cent more fighting range.)

Recent Developments in

INDUSTRIAL FURNACES

By H. C. HOTTEL

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THE reporting of technical advances in industrial furnace design from representatives of some twenty-two different groups is enormously stimulating to anyone interested in progress in a field which has changed so profoundly in the last two decades. The advances reported on could be grouped for discussion in many different ways. Perhaps as useful as any is to discuss them as evidence of progress in the application of those basic fields of engineering and science which underlie the whole field of furnace and kiln design. These are the fields of heat transfer, energy balance, mechanics (including fluid mechanics), materials of construction, chemical-process control, and combustion.

HEAT TRANSFER

Take first the field of heat transfer. There are today very few processes for which there is not a basis for a fair estimation of heat-transfer rate, in terms of local conditions; that is, with shape, size, and temperature of a heat-transfer surface specified, and with flow pattern, composition, and temperature of the ambient medium specified, there is today adequate knowledge for prediction of local heat-transfer rate. In many, shall I say most, furnace-design problems, however, there is little comfort, and less help, to be obtained from the foregoing statement. The missing information in so many industrial-furnace-design problems is the precise description of local conditions, a description which defies the engineer and forces him to accept empirical formulations of over-all transfer rates in terms of ends as against local conditions, and to refrain from attempting—yet—to disentangle the contributions of forced convection, free convection, nonluminous and luminous gas radiation, and solid-to-solid radiation in establishing the rate of transfer to the stock.

Examples of improved application of heat-transfer principles mentioned in the brief reports presented in this symposium include the following:

1 The increased recognition, in the heating of stock through a large temperature interval, of the existence of different ranges of permissible or preferred heating rates, leading to the use of energy sources at different potentials for different parts of the process. Such tailored heat-transfer rates are common in electric-resistor-furnace design; in fuel-fired furnaces they impose a more difficult design problem. Three of the contributions to this symposium referred to the heating of steel billets, all with the idea of focusing attention on what the billet can take rather than what the furnace can give.

One (Mawhinney) referred to the possible use of different levels of available heat as an approach to the problem of cutting down the period of high-temperature punishment of the surface; another (Bloom) described experiments which indicate what heating rates are now attained, as a preliminary to increasing them in certain ranges of operation; yet a third (Paschkis) is interested in calculations of unsteady-state heat flow to establish new criteria (or, rather, make more quantitative our old criteria) of permissible heating rates. A further example of the application of the principle of varying the potential at which heat is available comes from a contributor (Levin) who called attention to the induction-furnace field where a heating process is described in which a relatively slow combined heating-soaking operation is followed by a faster surface-temperature rise. A still further example of tailoring of the local transfer rates to the needs of the various parts of the furnace comes from a contributor (Kniveton) who describes the use of burner placement to control local rates.

2 The extension of the field of convection heat transfer, as evidenced by the contributor (Gamble) who gives 1750 F as a temperature level at which forced convection heating is now effectively used. Without trying to be too specific about where the dividing line comes, furnace designers have carved off the low-temperature region for convection and the high-temperature region for radiation.

In certain fields, notably refinery tube-still design, it has been said that the greater the fraction of the total heat transfer which is carried out in the radiant section of the furnace, the better the design, that is, the cheaper it is for a given job done. However, the inability of radiation to go around corners makes many heating operations benefit by increased use of convection as a technique of ironing out differences in heating rates of outside and inside surfaces.

Many problems of stock packing in relation to the establishing of local heat-transfer rates have been solved empirically and with good success. An opportunity is open for further improvement by a study of the principles involved, and the student of convection heat transfer will in the future find himself more and more concerned with problems in the field of aerodynamics. Many engineers know how to set up a flow system to obtain a convection coefficient of almost any desired magnitude. But most of them pay too much! Far fewer know how to obtain the minimum pressure drop consistent with a given heat-transfer rate.

3 The use of a different mechanism of heat transfer to do an old job (better, sometimes). This is what makes furnace design interesting. The use of salt-bath quenching involves a change both in the medium and the temperature level of the heat sink. The use of salt baths for protected heating of parts to 2150–2400 F (referred to by both Solakian and Rosseau) substitutes a liquid-film for a gas-film coefficient at the stock surface. The use of gas quenching with high-velocity jets (Cone) reverses the substitution; a gas film replaces a liquid film!

4 The protective cooling of furnace parts. Mention has been made of the water-cooling of critical furnace parts by two contributors. Higher-temperature forced-convection furnaces necessitate the cooling of fan shafts and bearings (Gamble); the introduction of electrode cooling glands and of water-cooling pipes in the roof rings of electric-arc melting furnaces has greatly increased furnace life (Watson).

So much for application of heat-transfer principles.

ENERGY BALANCE

No less important to good furnace design is the proper exploitation of generalizations which can be made from considera-

Summary of Panel Discussion on Recent Developments in Industrial Furnaces, held under the auspices of the Industrial Furnaces and Kilns Committee of the Heat Transfer Division at the Semi-Annual Meeting, Pittsburgh, Pa., June 19–22, 1944, of The American Society of Mechanical Engineers.

tion of the energy balance in furnaces. Logically, consideration of the energy balance precedes that of heat transfer; and such was the case in the industrial furnace field. Greater heat economy and better quality control shared with one another the credit for the early trend from batch to continuous furnaces. An example of a variation in that trend comes from a contributor (Webber), who describes the heat economy that is derived from combining several operations in a single furnace in such a way as to eliminate complete cooling between steps of the parts being processed. Here again the advantage is not solely that of heat economy; more important are the simplified handling and the quality control. Enormous opportunity exists for the integration of successive furnace operations, of which the brazing-heat-treating case is one example.

MECHANICS

It is easy to build something with so large a safety factor that the designer cannot possibly be embarrassed by a structural failure. The use of higher and higher temperature levels in various furnace operations leaves very little if any safety factor in many designs, and the designer is forced to make the best use of his materials. We cannot afford circular arches in the highest-temperature furnaces. We cannot afford rotational unbalance in fans for high-temperature recirculating furnaces, as one contributor has pointed out (Gamble). Controlled warpage of fans and furnace parts, which is referred to in the same contribution, comes from a more careful consideration of thermal as well as load stresses. Those in the industry who furnish new and better materials of construction are not magicians; and we must learn to use available materials more effectively.

Possibly able to be squeezed into the present general heading, if that is amplified to include fluid mechanics, is an important development mentioned by Dr. Robson, namely, the use of a Venturi injector to pump hot air with cold and thereby eliminate the hot fan. It will be interesting to watch the extent of application of this principle, lower in mechanical efficiency than a fan, but having its compensating advantages of simplified upkeep and a temperature level limited by refractories rather than by metals.

MATERIALS OF CONSTRUCTION

Progress in this very important field has been mentioned by several contributors. A listing of good alloys for various uses, and of cheaper, and in many cases good enough, substitutes for alloys has been made (Sayles). A most interesting research (Stafford) on the adverse effect of reducing gases, and even of CO_2, on the load-bearing properties of insulating firebrick doubtless explains many failures which have previously been classed as phenomenal. Let us hope that here, as so often is the case, the acquisition of quantitative knowledge concerning a deficiency is a predecessor to its cure. Other interesting examples of progress in materials of construction are the development of better electrode alloys for immersed-electrode salt baths, and better refractory pots for the same use (Solakian, and Rosseau). I do not doubt that some of the reticence concerning new materials of construction is a consequence of their being on the secrecy list for the duration. We may hopefully expect the war to have uncovered new materials of engineering.

CHEMICAL-PROCESS CONTROL

Chemical-processing furnaces as such have not come in for discussion in this symposium, but any heating operation involving a material which requires surface protection obviously presents a problem of chemical control. Four contributions touched on this problem. Bright gas-quenching, recarburizing, use of neutral atmospheres for clean forging, and gas-pickling have been mentioned (Cone). Salt baths offer another means of protected heating. Protection by exploiting the differences between the activity of hot and of cold atmospheres is a possibility in induction-heating (Levin). Protection by simple combustion control to prevent unnecessarily high excess air has been mentioned by one contributor (Mawhinney). This is a particularly interesting example because it is so old and yet so important.

It is doubtful if any single advance in furnace design can yield as much in dividends as increased control over the air-fuel ratio. To talk about other advances while there is so much room for improvement here is faintly similar to discussing the calculus before one can add.

COMBUSTION

I come last to the process which so many have for so long taken for granted. References to patterned combustion by the use of small burner combustion-chamber combinations (Kniveton), and to the advantages of better combustion in steel-reheating-furnace operations (Mawhinney), constitute the only mention of trends in combustion. If we were all electric-furnace engineers there would justifiably be little interest in combustion. I am convinced that electric furnaces can do some things better than fuel-fired furnaces and certain that they merit an important place among industrial-furnace types. I am also convinced that fuel-fired furnaces have given up to the electric furnace some fields of use which they need not have given up if the combustion process were under better control.

To burn fuel and then to transfer heat from it presents a succession of two problems, each moderately well known. To carry out the operations simultaneously is to raise much more difficult problems. The result is cheaper operation. Some operations put such a demand on the heating schedule as to be most safely handled by separating combustion and heat transfer. Some are so gross, so insensitive to conditions of atmosphere and transfer rate, as to be easily handled by a furnace which combines combustion and heat transfer, even though poorly. Some are borderline cases, able to be handled in fuel-fired furnaces which mix the combustion and the heat-transfer process providing they do a proper job of it.

Consider the fact that only in the last few years has there been any precise knowledge of the mixing pattern around an open fuel-gas jet, that we do not today have the complete story of mixing in a simple jet with orifice-controlled air injection and a certain amount of self-generated recirculation. Flame placement, space requirement for combustion, perfect mixing so that combustion products at the front where they pass over the stock are uniform in composition, not only judged by comparing two long-time samples, but even by comparing snap samples taken in 0.01 sec, i.e., uniform in composition as judged by a Maxwell demon—these are problems about which we know so little.

I am not speaking out of turn in calling your attention to the fact that we have gas-turbine combustion power plants that fly—the newspapers and magazines have described them. It takes little imagination to see what enormous problems in combustion-pattern control have had to be solved to make such power plants sufficiently compact to be practical. It takes but a little arithmetic to see that combustion rates attained are completely outside the field of industrial-furnace experience, and it takes but a brief search of the literature to see how little there was in the way of guidance to the solution of the problems involved.

We may expect, then, an enormous impetus to industrial-furnace design from our war experience, and the forward-looking furnace designer will recognize potentialities of application of the new knowledge in the fields of better atmosphere control, better flame placement, and consequently a closer approach to the ultimate job of tailoring the combustion and heat-transfer process to the needs of the stock.

STATE AND LOCAL FINANCE[1]

By ARTHUR A. BRIGHT, JR.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

THERE are 165,048 units of government in the United States other than the federal government, including the states, counties, municipalities, school districts and a variety of other special governmental units. The dynamic aspects of economic and social development have far outdistanced progress in many of these governments, with antiquated organizations, overlapping of functions, and insufficient tax bases making it difficult or impossible to organize financial activities efficiently and to provide adequately for essential services. The financial problems of the smaller units of government tend to be cumulative rather than critical, but after a long period of gradually increasing difficulty a realization may dawn that financial organization and conduct of financial affairs are outmoded. By that time no easy solution may be available.

A new book by Hansen and Perloff entitled "State and Local Finance in the National Economy" has recently been published.[2] It constitutes an integrated discussion of both the detailed and the broad problems of state and local finance with suggestions for their remedy, emphasizing the national point of view. The first two parts of the book summarize the specific problems faced by state and local units in their raising of revenue and allocation of expenditures and suggest solutions for these problems. Part 3 is devoted primarily to an enlargement of the scope of the authors' views on governmental fiscal policy to include the state and local budgets as well as that of the federal government. In a sense this second aspect of the book is an expansion of and supplement to a previous book written by Hansen alone.[3]

PROBLEMS IN THE FINANCING OF SMALL GOVERNMENTAL UNITS

The problem of raising an adequate amount of revenue to provide satisfactorily the essential public services is not equally difficult for all governmental units. Those states, municipalities, and other units with high per capita incomes are able to perform the necessary governmental functions at a relatively low real cost per capita in comparison with the rest of the country. In other areas where economic capacity and per capita income are smaller, standards of service in education, health, social security, and welfare are generally inadequate, even though the proportion of per capita income devoted to the support of state and locally performed services has typically been greater in the poorer states than in the richer states.

It is well known that state and local taxes are regressive in the lower income brackets and are at most proportional in the higher income brackets. The limited use by the states of personal income and other progressive taxes makes it difficult to achieve an equitable tax burden. Discriminatory and unsound state taxation on business and trade also tends to interfere severely with the normal flow of commerce. Where each state establishes its tax laws without reference to their broad nationwide implications, barriers are erected between the states that are as real as those between nations.

The difficulties just cited are important from a national point of view in that they hinder the most efficient utilization of resources, but there is an additional source of waste in the haphazard or inadequate control of state and local finance over the business cycle. During times of recession, when national income is declining and private investment is falling, it has been characteristic in the past for the smaller governmental units to curtail their expenditures and attempt to maintain annually balanced budgets. During times of prosperity when revenues are increasing, the smaller governments have traditionally expanded their expenditures and embarked upon large projects of public investment. Both of these policies reinforce and widen the fluctuations in total economic activity in the country over the period of the business cycle.

It is not easy to remedy these situations. A modernization of governmental organization and policy is extremely difficult to achieve. Moreover, in many instances it is extremely difficult even with a proper organization to restore finances to a sound basis where the economic capacity of the geographical area included within the jurisdiction of the government is not subject to redevelopment or expansion. Virtually all experts advocate reorganization into compact metropolitan units or into other organic units large enough to provide essential services at reasonable cost to the inhabitants. Moreover, a restoration of economic capacity and an increase in taxable values through the replanning and rebuilding of integrated metropolitan districts and the development of river valleys is usually a profitable governmental investment when it is efficiently carried out.

The physical solutions to the ills of most municipalities and even counties and states are usually fairly apparent. The most difficult problems are in connection with the restoration of smaller government finances to a sound basis. For that restoration it seems quite clear that intergovernmental co-operation is essential. Without the assistance of governments with broader tax bases and powers, it is impossible for the financially embarrassed smaller units to raise sufficient funds to carry on large-scale programs of reconstruction. Hansen and Perloff call for federal grants-in-aid as an essential part of reform at the lower levels of government, the funds to be distributed on the basis of need rather than on the basis of population or matching equal appropriations by the subordinate units.

Hansen and Perloff also believe that the federal government should underwrite minimum service standards by both state and local governments. The poorer states simply cannot afford to raise their standards of education to an adequate level, pay satisfactory social-security benefits, etc., without outside assistance. The need for these services is not just as great as that in wealthier states but is actually greater.

The writer is in general agreement with all findings in this section of the book, and it seems probable that most readers will similarly concur. The widespread need for the improvements referred to is quite apparent. The book does serve, however, as a convenient compilation and summary of the detailed problems of state and local finance and some of the suggested remedies.

STATE AND LOCAL FINANCE AND FISCAL POLICY

With respect to fiscal policy, the present work extends the scope of the discussion in Hansen's earlier book from the federal government alone to include state and local governments. A positive fiscal policy is advocated as an important measure in the stabilization of economic activity. This involves a planned

[1] One of a series of reviews of current economic literature affecting engineering, prepared by members of the Department of Economics and Social Science, Massachusetts Institute of Technology, at the request of the Management Division of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS. Opinions expressed are those of the reviewer.

[2] "State and Local Finance in the National Economy," by Alvin H. Hansen and Harvey S. Perloff, W. W. Norton and Co., Inc., New York, N. Y., 1944, $3.75.

[3] "Fiscal Policy and Business Cycles," by Alvin H. Hansen, W. W. Norton and Co., Inc., New York, N. Y., 1941. (Reviewed in MECHANICAL ENGINEERING, April, 1942.)

fluctuation in governmental revenues and expenditures over the course of the business cycle in an effort to ameliorate or offset booms and depressions in the private sector of the economy. To the extent that this is possible a high level of national income and reasonably full employment can be maintained continuously.

If individual and corporate savings are not promptly invested, there tends to be a cumulative decline in national income and consumption. To reverse the downward course of business during a recession, it is necessary for greater numbers of dollars to be put into circulation. In part this can be achieved by reducing taxation and increasing the abilities of individuals and businesses to put dollars into circulation. In part it can be done by increasing governmental expenditures. Hansen believes it is necessary for the government to take less money from circulation than it puts into circulation during depressed years.

An equally important aspect of a positive fiscal policy is that when private business is moving toward an inflationary boom the reverse policy should be followed by the federal government. To check uneconomical price rises it is necessary that more dollars should be withdrawn from circulation through taxation than are put into circulation by governmental expenditures. In this way, by deficit financing during depressed periods and the retirement of public debt during time of business boom, it is to be hoped that national income can be maintained continuously at a high level without the wastes of cyclical fluctuations.

If these surpluses and deficits should cancel each other, a balanced federal budget could be achieved over the course of what would otherwise be a business cycle. This might or might not permit a gradual retirement of the national debt, but in any event it would hold the debt and the amount of interest charges constant while national income increased as a result of both population and productivity increases. The net burden of such a debt would gradually decline. Hansen, optimistic in the face of his own pessimism, asserts that even a debt which increases gradually over time is not an insufferable burden *provided* that national income rises by a larger percentage.

Hansen's argument in connection with fiscal policy appears to be based upon three assumptions: (1) It is desirable to avoid cyclical fluctuations in business; (2) in the absence of federal intervention periodic business cycles will continue; and (3) in the absence of a positive federal fiscal policy no other federal policy or policies under an enterprise economy would be sufficient to iron out the cycle. There is general agreement with respect to the first assumption. The second assumption appears justified by past history. The third assumption is more debatable. Hansen does not deny that other policies, which are not discussed in this book, are important; rather he believes that a vigorous fiscal policy must be employed along with other policies or they will not be sufficient to even out the cycle. Hansen is one of the outstanding exponents of the use of a positive fiscal policy, and in this book the reader will find a clear and understandable exposition of its purpose and effect.

Whether or not one agrees completely with Hansen's views, it is clear that governmental fiscal policy, whether formed consciously or unconsciously, is important to the level of business. The writer believes that other policies are very important in business stabilization but that an adequate program for stability must include a carefully worked out fiscal policy. Hansen's case seems very strong in many respects, and someday it may be completely accepted by the nation. At present it would seem desirable, for a variety of reasons, however, to achieve a cyclically balanced budget.

It is evident that if a positive fiscal policy is to be employed effectively by the federal government to avoid violent contractions and expansions in private business, the co-operation of state and local governments is required. The smaller units of government should not curtail their services during times of depression, which are normally when they are most needed. It is extremely difficult for the smaller governments to maintain their expenditures while tax revenues are shrinking, particularly in the face of cries for governmental economy and a balanced budget. Nevertheless, this is necessary if state and local governments are not to accentuate cyclical fluctuations. On the contrary, during times of prosperity, when a balanced budget is easy to achieve, the pressure is normally for increased expenditures or reductions in taxes rather than for reductions in debt or the accumulation of reserves. This also accentuates cyclical fluctuations and requires a new national approach to local finances.

In order that state and local governments may behave in a manner designed to iron out the cycle, it seems essential that they receive the aid of the federal government both in over-all planning and in financing. With this in mind, Hansen proposes new patterns of governmental taxation and spending. Federal grants-in-aid would form an essential part in the pattern of expenditures. With respect to federal taxation, Hansen calls for an elimination of corporate excess-profits taxes and other drastic revisions in corporation taxes, with a primary reliance upon individual income, estate, pay roll, and a few selected excise taxes. At the state level it seems essential that the general sales tax be abolished and state taxes on business be materially improved with a much greater reliance upon personal income and death transfer taxes. Motor-vehicle, gasoline, tobacco, and liquor taxes would continue to be important. Local governments are unfortunately very limited in the tax revenues available to them. After federal and state taxes have been levied, there are few sources left to smaller units of government. It would seem necessary that there be continued reliance primarily upon property taxes, although the standards of assessment and collection need general improvement.

Effectiveness in Engineering Training

(Continued from page 589)

standing of approved procedures is shared by the instructors and the supervisors, and that the supervisors are in agreement with the material as taught.

In large engineering departments, it is not uncommon for many different interpretations of a company-approved procedure to exist. Even though the interpretation selected by the instructor is the one generally accepted, he is still open to criticism by those differing in opinion. For these reasons, it is believed that supervisors must be fully informed of the objectives of the training program and also in the interpretations of executive directives.

Supervisors can help the training program greatly, and also themselves, by contributing to it. Who can better determine what is lacking? Who can give better counsel and advice to the employee? Who can better impress the employee with the necessity for constructive preparation for advancement?

Above all, employees who have acquired additional ability through training, or any other way for that matter, must be allowed to use it on the job. Too frequently a careless supervisor will overlook an increased capacity in a man. Such neglect is of course very discouraging to the employee who will then likely become indifferent to any further attempt to upgrade him.

In light of the foregoing, the success of a training program depends as much upon the interest and effort expended by plant supervision as it does on those engaged in actual training.

In summarizing, it should be repeated that there are an infinite number of degrees of effectiveness. Only if a training program is carefully conceived, fully supported, properly instructed, thoroughly organized, and the resulting increased abilities on the part of the student efficiently utilized on the job, can it be truly effective. But, by whatever training paths taken, final effectiveness can only be measured in terms of increased production.

COMMENTS ON PAPERS

Including Letters From Readers on Miscellaneous Subjects

Geo. A. Orrok

To the Editor:

Thirteen years of intimate association with Geo. A. Orrok, engineer, have been an experience of rich and lasting value. My appreciation and gratitude for those years, so full of professional inspiration and warmest friendship, can only be exceeded by my daily sense of loss in the passing of "Uncle George."

To have enjoyed this long period of closest association with an engineer of his international reputation and high and generous character, was indeed a rare privilege, and one never to be forgotten.

Much has been published regarding his professional life, and his record of extensive and versatile accomplishment. There has not been the slightest exaggeration in any of these accounts, which are a source of pride to his astonishingly large number of friends and acquaintances in the many countries of the world where his work and personality were so favorably known.

I need add nothing to all of this, but as his professional associate and close friend, I desire publicly to express my admiration and respect for Geo. A. Orrok and to contribute these few words in honor of a great engineer, a true gentleman, and a very dear friend.

David Moffat Myers.[1]

[1] Consulting Engineer, New York, N. Y. Fellow A.S.M.E.

Biomechanics—A New Approach to Airplane Safety

Comment By P. E. Hovgard[2]

This paper[3] treats of a subject so pertinent to modern aviation that not to realize its proper significance would be a fallacy, not only in the realm of biomechanics, but also in the realm of developments that must be forthcoming if aviation is to progress from the safety-factor point of view.

During the act of flying an absolute degree of co-ordination is required between mind and body, and it is to protect and sustain this co-ordination that modern influence in design of aircraft is favoring the pilot.

Increased performance of aircraft now exceeds the normal range of human adaptability. Man, primarily, was constructed for a terrestrial life, and any effort to overcome this status involves a mechanical procedure to maintain the balance between body function and body accommodation.

The greatest physiological changes involving the body in other than normal flight, are as follows:

1 Variations from straight-line flight at high speeds.

2 Collision of aircraft with earth, or another body.

Aircraft are built to take stress and strain, but people are born, and have no control over design for any given condition. Speed at altitude demands obedience to certain laws of Nature, as outlined by the flight surgeon, and Nature exacts a heavy penalty of any individual who violates them. Therefore, we must protect the human body from its own limitations when in flight; and it is the duty of the biomechanics group to treat with this problem in accordance to the demands by recognizing the human limitations. In other words, the airplane designer and builder must be well informed of the body accommodations, its normal function, and limitations, and build, not to eliminate this condition, but to compensate for it as it pertains to the human body.

The airplane builder, not being a surgeon, draftsman, engineer, or research worker combined, may ask, "Where may I obtain this information in order to construct along the lines outlined, and how may I recognize the involved human equations?" The answer lies in the Biomechanics Committee, as representing the pool of research information.

The author has stated: "The pilot and passengers present different problems. The latter have a choice of positions. In certain ditching processes they are advised to face the rear of the cockpit and may thus reduce head and extremity hazards." Let us examine this statement more fully, and in relation to a passenger airplane. The present seating arrangement of a passenger airplane is to face forward. Results of forced landings, or crashes, in the past seem to indicate this arrangement as inadequate, in that the body is thrown forward, the neck receives a snap jerk, and the head travels forward, usually to be injured against some inanimate object. The gross summation, therefore, presents a series of questions, one of which is: "Is the seating arrangement adequate, or, is the seat faced in the proper direction to supply maximum body tolerance in the event of a crash?" The answers to this question may vary, but just one basic principle is involved, and that is: "Has construction been along lines to compensate the body for this unforeseen stress?"

Visualize, for a moment, the picture of a passenger asleep in his (or her) seat; a sudden jolt; you have the answer. Now let us visualize, for instance, a passenger asleep in a seat facing opposite the path of flight, i.e., opposite the path of crash force. A sudden jolt occurs. Is the body thrown forward? Does the neck receive a snap jerk? And does the head travel forward to be injured against some inanimate object? Perhaps to a small degree, but never in proportion to the forward-seating arrangement.

The point may be raised that most passengers cannot ride backwards. This may be true in the case of the train passenger, but not so applicable in the case of the airplane passenger. In the case of the latter, the disturbing factor for the train passenger does not exist, or just momentarily so; namely, an association of visual objects closely related to vision in panorama at close range without fixation of sight, thereby, causing a disturbing influence to the semicircular canals of the middle ear, the balancing organs for the body. The rearward-seating arrangement might be questioned because of the attitude of the airplane while on the ground, as this would place the passenger in a most uncomfortable position due to the floor slant in the conventional passenger airplane, when using the tail wheel. This condition would be entirely eradicated by the use of the tricycle land-

[2] Curtis Wright Corporation, Airplane Division, Buffalo, N. Y.

[3] "Biomechanics—A New Approach to Airplane Safety," by C. M. Gratz, Mechanical Engineering, May, 1944, pp. 313–314.

ing gear, where the floor would be parallel with the ground.

The author states that head injuries occur in 90 per cent of major crashes. This, in particular, refers to the flyers of our fighting forces, and offers an acute challenge to the biomechanics group.

The author also states that crash landings are better avoided than controlled and safety advances when they are controlled, where they cannot be avoided. By this is meant the involvement of engineering principles in relation to the physical accommodation of the pilot and crew, or passengers, and can be illustrated by any appliance that will supply compensation for known body reactions. This, too, includes those factors which cause body fatigue, such as noise, vibration, poor vision, etc., as a physical hindrance to good judgment. To illustrate further the fatigue factors: The present general arrangement of instrument panels is not too conducive to good pilot instrumentation without causing fatigue. The answer may possibly be found in our failure to recognize the normal path of sight travel, as in reading. Those instruments which follow in sequence of importance for operation should possibly follow the horizontal sight path from left to right, rather than vertically, as many of them are placed today. It is obvious that any incorrect application of this principle may well prove a fatigue factor to pilots.

An interesting item is that the Mayo Aero Medical Research Unit draws little or no line of demarcation between pilot fatigue and shell-shock, in that both are associated with physical and nervous collapse.

The writer believes that it is necessary to recognize the human factor and its limitations, and to design and build airplanes which embody features that will compensate for the condition rather than attempt to avoid it.

COMMENT BY ALEXANDER KLEMIN[4]

No airplane design can ever be completely immune to crashes. However well advanced biological knowledge of the human structure may be, an airplane designer could not and would not design aircraft based in any way on calculations of the elasticity or strength of human fibers, no matter what wealth of information were presented to him by the biological and medical experts. He still would prefer to protect the body rather than to count on its resistance to shock.

Nevertheless this paper is extremely valuable in setting forth clearly which parts of the body are vulnerable, and which must be greatly protected. Just the suggestions that he makes would be sufficient indication for a careful designer that he must above all avoid head injuries and eliminate protuberances at the level of the head. Also, it is evident that he must provide such safety equipment that the body is held on the seat and is not projected forward.

While on the one hand, the engineers should continue to design the cockpit to reduce stresses in crashes, anything the medical men can tell us along these lines will be invaluable and should be carefully studied and made use of in airplane design.

[4] Guggenheim Research Professor, Daniel Guggenheim School of Aeronautics, New York University, New York, N. Y. Mem. A.S.M.E.

Welding and Riveting Compared

TO THE EDITOR:

Engineering is an exact science. It is possible, however, for engineers to be very inexact. The attitude of many engineers toward arc welding is an illustration.

Arc welding has been a tremendously valuable manufacturing tool for the last fifteen years. The results obtained in that time should determine for any engineer its value. However, minutiae of no actual importance in the welded structure are still being discussed as important, at great length, with much heat. Many people of common sense view the disagreement as casting a question on all welding. As a result, engineering and welding as a whole are losing caste. Arc welding also is under suspicion it does not merit.

As an example, let us compare objectively welding and riveting of a joint. No one either in or outside of engineering doubts the known efficiency and soundness of a riveted joint. Therefore, in this case we are comparing arc welding with a known standard.

First, every arc-welded joint of full section in mild steel is stronger than the plate. No riveted joint can be made under any conditions which would be as much as 95 per cent of the strength of the plate.

Second, the metal in the welded joint has an elastic limit in excess of 50,000 psi. Mild-steel plate as rolled has an elastic limit under 40,000 psi. Hence, any stress of a welded structure which will stretch the plate will not affect the welded joint. The riveted joint, however, in such a case would be destroyed.

Third, any welded joint which in being X-rayed would show any void, no matter how small, would be immediately chipped out and rewelded. Yet every riveted joint has at every rivet a void tremendously greater than would be found in any commercial welded joint, yet it is trusted without question.

Fourth, any welded joint which would have any undercut would be rewelded and the undercut eliminated. Yet any riveted joint which it is desired to make tight is calked and the plate is undercut by the calking tool much more than would be found in any welded joint. Obviously, this is never rewelded.

Fifth, any welded joint under commercial conditions can be made at a fraction of the cost of a riveted joint which even approaches it in strength. Yet riveting is still standard in the case of much engineering construction such as bridges, tank cars, boilers, etc.

Sixth, engineers reject weld deposit with an elongation of 15 per cent. Yet no riveted joint will stretch at all without destruction.

Perhaps engineering is not an exact science after all.

J. F. LINCOLN.[5]

Pressure Loss in Elbows and Duct Branches

TO THE EDITOR:

Some errors occur in a recent paper[6] by the writer, and some of the notations are also unusual. The corrections to be made are as follows:

Q denotes "volume rate of flow" throughout the paper.

On p. 177, in the nomenclature, the formula, $(p_1 + {}^1/_2\,\rho V_1^2) - (p_2 + {}^1/_2\,\rho V_2^2)$, is to be omitted.

On pp. 178 and 181, Equations [II] and [18] should read: $2h_{01} = \lambda_1 V_0^2 + (2\lambda_2 - \lambda_1) V_1^2 - 2\lambda_2 V_0 V_1 \cos\alpha'$.

On p. 179, Equation [8] should read: $p_1 + {}^1/_2\,\rho V_1^2 = p_2 + {}^1/_2\,\rho V_2^2 + H\rho$.

On p. 181, Equation [10] should read: $2h = (1 - \eta)(V_1^2 - V_2^2)$.

On p. 181, Equation [15] should read: $2h = \xi (V_1^2 + V_2^2 - 2V_1V_2 \cos\alpha) + (1 - \eta)(V_1^2 - V_2^2)$.

On p. 182, the "Example" refers to separating flow. The proper value of the coefficient $2\lambda_2 - \lambda_1$ is 0.8.

The writer is indebted to Messrs. W. Doll, East Hartford; R. A. Banck, Detroit; and F. A. McClintock, East Hartford; for calling attention to these corrections.

ANDREW VAZSONYI.[7]

[5] President, Lincoln Electric Company, Cleveland, Ohio. Mem. A.S.M.E.

[6] "Pressure Loss in Elbows and Duct Branches," by Andrew Vazsonyi, Trans. A.S.M.E., vol. 66, 1944, pp. 177–183.

[7] Teaching Fellow in Mechanical Engineering, graduate School of Engineering, Harvard University, Cambridge, Mass.

REVIEWS OF BOOKS

And Notes on Books Received in the Engineering Societies Library

The Dynamics of Time Study

THE DYNAMICS OF TIME STUDY. By Ralph Presgrave, The University of Toronto Press, Toronto, Canada, 1944. Cloth, 6 × 9 in., 211 pp., 3 Figs., $3.50.

REVIEWED BY MARVIN E. MUNDEL[1]

THIS book is an analysis of the fundamental principles of measurement as related to stop-watch time study, a critical analysis of the most widely used existing systems, an exposition of known data regarding the range of human effort, and suggestions for an "effort" rating plan to produce more consistent stop-watch time study. Although this reviewer does not feel that the effort-rating plan as presented by Mr. Presgrave is at all an answer to the problems developed by the author in his critical analysis of time-study rating systems, he does feel that this book represents an important step toward the development of more valid stop-watch time-study procedures.

A stop-watch time study is the determination of the amount of work that will be accomplished in a given time, with a given method, under given conditions of work, by a specified type of operator with a specified familiarity with the job and with a specified skill, working at a pace that will produce a specified physical effect upon himself. I do not believe Mr. Presgrave would quarrel with this definition. Mr. Presgrave says, "... time study ... is concerned fundamentally with two measurements and with two alone. One of these is the measurement of elapsed time, i.e., the true basic measurement. The other is the measurement of the speed of the operator's motions, i.e., the measurement of the correction factor. There can be no other basic measurement and no other correction factor within the concept of time study as measurement."

It is with the second measurement, that of the correction factor, that Mr. Presgrave, as are many time-study workers, is most concerned. Mr. Presgrave makes a complete analysis of methods of arriving at this correction factor by the application of mathematical formulas, by the application of external correction factors derived from leveling, by rating, by element selection, and by methods involving a comparison of specific motion times with predetermined standards. Since these three categories include practically all of the time-study rating systems in use at the present time their discussion includes information which should be of interest to everybody working in the field.

From his critical analysis of the defects of most existing systems Mr. Presgrave concludes, "All of this boils down to the conclusion that rapidity of movement is the only factor which has a direct mathematical relationship with the productive range." He adds, "It may still be convenient to use the term *effort* so long as we understand that it refers to what might be called 'tempo' in lieu of 'speed' which has unfortunate associations." (This reviewer objects strenuously to the use of the word *effort* inasmuch as it has so many connotations to the average individual that its use may be called nothing but a smoke screen. "Rate of activity" itself would be a much better term.)

Making use of known data concerning the range of human ability to walk, type, and deal cards the author develops three standards of "effort" and uses these to assign percentage values to the entire range of effort on each of these three jobs as well as a cross comparison between them. A sample of the confusion that results from the use of the word "effort" may be best understood by quoting from Mr. Presgrave" ... pretending that walking is a factory job, he (the time-study engineer) will very soon find that three miles per hour calls for effort of a degree that appears low and that is most reasonable as a starting point for incentives. He will also find that a speed of 3.8 to 4.0 miles per hour requires an added effort that could surely be maintained day after day if proper compensation for fatigue were made. He would agree that this speed of 25 to 35 per cent above standard could be fairly expected of most people providing the incentive element and pay were in proportion." This is almost a return to systems in which the time-study engineer determined what is "a brisk maintainable pace" for the job. Brisk is tempo but maintainable is effort in its more common sense.

In the development of Mr. Presgrave's effort-rating plan he asks, "Can the determination of any mathematical factor by judgment ever be regarded as measurement in the strict sense?" . . . . much depends on receiving a rational answer — to —

1 "Is it possible to give a universal mathematical value to operative speed?
2 "Is it possible to determine this value by mental processes only?
3 "If this last is possible, can it apply to all types of manual work?
4 "Can it be done consistently over the whole range of speeds?
5 "Is the method consistent as between different observers?
6 "Is it reliable as between operators?
7 "How can it be learned or taught?
8 "Is everyone capable of rating?"

In answering these questions Mr. Presgrave falls into a series of fallacies which have become very popular of late. He demonstrates that after establishing and showing to a group a standard for a job such as walking, card dealing, or typing, it then becomes possible for the group with a relatively good degree of consistency to evaluate the speed demonstrated by an operator working at some different pace. However, it is still necessary to redefine the standard for each job. If the standard for each job were known, the rating of a stop-watch time study would hardly be necessary.

The tempo or speed on each job will vary with the muscle groups in use as well as the amount of weight involved, the eye-hand co-ordinations, and the degree of sensitivity required in handling the parts. Hence the mere measurement of tempo against standard tempo is insufficient.

In one of the concluding statements Mr. Presgrave says, "He (the time-study man) will have confidence in it (effort rating) because he knows precisely what quality he aims to measure and what is the scope of his ability to measure that quality. In the opinion of this reviewer Mr. Presgrave's effort-rating plan resembles giving a person a foot ruler, and teaching him how to read it. In this situation the person knows that he is going to measure length and is confident of his ability to measure length within the error of handling the ruler. However, this does not provide the wielder of the ruler with any information regarding from where to where he is to measure. Effort rating offers no guidepost to time-

[1] Assistant Professor of Industrial Engineering and Staff Advisor, ESMWT Program, Purdue University, Lafayette, Ind. Jun. A.S.M.E.

study measurements unless a standard for the job is already defined. However, in this case the function of a time study has already been performed (which is not the case in the industrial situation).

Despite the rather strong criticism of the time-study rating plan developed by Mr. Presgrave this reviewer believes the first part of the book in which Mr. Presgrave critically analyzes the existing time-study plans should be of interest to everybody working in this field wherever time study is practiced or, as is altogether too often the case, malpracticed. An analysis of time study as measurement has been mostly lacking in our field which has been considerably concerned with "proof-of-the-pudding" measures which are almost entirely vitiated by such additional factors as operator capriciousness, soldiering, and withholding of output due to fear of piece-rate cuts. I do not believe it is any exaggeration to say that if all time-study workers were to analyze critically their procedures in view of Mr. Presgrave's remarks, there would be material progress in our field.

Applied Safety Engineering

Applied Safety Engineering. By H. H. Berman and H. W. McCrone. McGraw-Hill Book Co., Inc., New York, N. Y., 1943. Cloth, $5^1/_4 \times 8^1/_4$ in., 189 pp., $2.

Reviewed by Crosby Field[2]

THE use of examples as an aid to the understanding of general principles long since has found its way into standard methods of pedagogy. This handy little volume, however, goes much further and devotes substantially its entire space to the study of cases utilizing a thin thread of text to tie them together.

This adaptation of the case method, so commonly used in legal training, is of prime importance in times like these when the rapid acquirement of very specialized skills is most important no matter how precisely limited those skills may be. For this objective "Applied Safety of Engineering" is admirable and is highly recommended to those who want a quick "practical" outline. This little volume is a natural outgrowth of the present-day method of rapid training for industrial safety. It is written in clear everyday language and is not only a primer but a concise reference book which should be useful throughout the career of the safety worker.

The authors are H. H. Berman, safety engineer, Consolidated Gas Electric Light and Power Company of Baltimore, and H. W. McCrone, field engineer, Baltimore Safety Council, and both are instructors in Safety Engineering, University of Maryland.

The objective of the book is stated very well in the preface and W. T. Cameron, chief safety adviser, Division of Labor Standards, U. S. Department of Labor, in his foreword has clearly defined the field of usefulness of the book.

In welcoming this unusual treatment of a topic, it might be well to point out some of the disadvantages of the method as well as to give full acknowledgment to its advantages, For example, the authors say:

> The handling of accident cases is thus revealed as a common denominator in the formula for successful safety work, with the degree of success depending largely upon the Safety Engineer's adroitness in dealing with the cases individually and collectively. Since safety engineering deals with cases, "Applied Safety Engineering" is presented on a modified case basis.
>
> It should be recognized that this text is not intended to be an exhaustive treatise on industrial safety engineering, nor is it offered as a magic cure-all for those problems that beset the Safety Engineer. It has been purposely limited to a few phases of activity that are considered to be the most important and yet seem to be the most difficult to put into practical operation. Throughout the text emphasis is placed on the "how" of safety engineering, since it is believed that the "what" and "why" are much more adequately treated in extant safety literature.

In spite of this clear statement it is feared that the safety engineer will be tempted to confine himself to the book and, as such, will use it to the exclusion of studies of the broader and more important general topics.

This reviewer has had occasion to deal with several hundred safety engineers and safety men on a professional basis over a period exceeding thirty-five years. Taken as a class their usual and main defect is that their general industrial and process knowledge is limited. Usually they have specialized too intensely and because of that are unable to anticipate the hazards inherent in a process or equipment prior to its introduction or installation. Nothing in this book points out this major defect.

One other very grave charge is that the book is self-centered about the safety engineer and directs that the safety engineer "co-ordinate" a safety program and implies that the safety engineer on safety matters has some sort of line, command, or operating responsibility as the "master" or "boss" function is variously called. To be sure he states, "Safety action is not unilateral. Workers, supervisors, and executives must shoulder their share of accident-prevention work." And again, "Every member of the personnel from the highest executive down has to respond by supplying that degree and sort of action called for in the light of his assigned responsibilities and duties."

Other similar quotations indicate the recognition of the fact that the line or operating chain of command is responsible for all matters. There is missing the concise and emphatic statement that the safety engineer is not the "boss." In a properly set up organization, the safety engineer is purely a staff adviser to the production or management ("line") executive. The higher the man to whom he reports, the higher is the safety level likely to be. In spite of the injunctions scattered throughout the book to obtain "co-operation," the fact remains that the tenor of the book is such as to lead the safety engineer into the position of trying to "boss" the safety program and, in this reviewer's opinion, that is a fatal situation.

The book nevertheless is a most welcome addition to literature and well deserves its name of "Applied Safety Engineering."

[2] Colonel, assistant director of safety, Ordnance Department, A.U.S., Chicago, Ill. Fellow A.S.M.E.

Books Received in Library

Composite Aircraft Manufacture and Inspection. By L. C. Michelon and R. J. Devereaux. Harper & Brothers, New York, N. Y., and London, England, 1944. Cloth, 8×11 in., 547 pp., illus., diagrams, charts, tables, $6. The aim in this book is to describe the manufacture and inspection of composite aircraft. It covers the basic materials used, metals, wood, plastics, and fabrics, and the Army-Navy aeronautical specifications covering them. It discusses the processes by which they are fabricated into finished structures and presents the methods and instruments used in inspecting them. The book is fully illustrated and covers the subject comprehensively.

Heating, Ventilating, Air Conditioning Guide 1944. American Society of Heating and Ventilating Engineers, New York, N. Y. Fabrikoid, 6×9 in., 1168 pp.; Roll of Membership, 104 pp., illus., diagrams, charts, tables, $5. The new edition of this reference book follows the pattern of previous ones. It has, however, been thoroughly revised and many new data added, to bring it up to date. A new chapter on marine heating and ventilation has been added. It maintains the position of practical guide to good practice.

Library Services

ENGINEERING Societies Library books may be borrowed by mail by A.S.M.E. members for a small handling charge. The Library also prepares bibliographies, maintains search and photostat services, and can provide microfilm copies of any item in its collection. Address inquiries to Harrison W. Craver, Director, Engineering Societies Library, 29 West 39th St., New York, N. Y.

A.S.M.E. BOILER CODE

Interpretations

THE Boiler Code Committee meets monthly for the purpose of considering communications relative to the Boiler Code. Anyone desiring information on the application of the Code may communicate with the Committee Secretary, 29 West 39th St., New York 18, N. Y.

The procedure of the Committee in handling the cases is as follows: All inquiries must be in written form before they are accepted for consideration. Copies are then sent by the Secretary of the Committee to all members of the Committee. The interpretation, in the form of a reply, is then prepared by the Committee and is passed upon at a regular meeting.

This interpretation is later submitted to the Council of The American Society of Mechanical Engineers for approval after which it is issued to the inquirer and published in MECHANICAL ENGINEERING.

Following is a record of the interpretations of this Committee formulated at the meeting of June 23, 1944, and approved by the A.S.M.E. Council on August 11, 1944.

CASE NO. 979

(Reopened) (Special Ruling)

Inquiry: Due to the improvements in design, construction, and materials, may the design stresses for Pars. U-68 and U-69 vessels and the joint efficiency in fusion-welded construction be increased from present Code requirements?

Reply: It is the opinion of the Committee that existing Code rules shall be complied with except as herein modified.

The maximum allowable working pressure for welded or seamless unfired pressure vessels, and for tubes for use in such vessels, may be determined as follows:

(*A*) With the exceptions stated below, the shells and heads of Par. U-68 vessels may be allowed a joint efficiency of 95 per cent, and the shells and heads of Par. U-69 vessels a joint efficiency of 80 per cent, and may be designed by using the formulas in Pars. U-20(*a*) and (*b*), U-36, U-39, and U-59 with maximum design stresses given in Table U-2 multiplied by 1.25, and to the calculated thickness for steam, water, and air vessels shall be added a corrosion allowance of one sixth of the calculated thickness, or $^1/_{16}$ in., whichever is the smaller. Vessels in other corrosive services shall be provided with appropriate corrosion allowances. The following restrictions shall apply to all such vessels:

(1) The weld reinforcements shall be removed flush with the surface of the plate for all Par. U-68 vessels. In all cases, for both Pars. U-68 and U-69 vessels, where edges of unequal thicknesses are abutted, the edge of the thicker plate shall be trimmed to a smooth taper extending for a distance at least four times the offset between the abutting surfaces so that the adjoining edges will be of approximately the same thickness. The length of the required taper may include the width of the weld. Other joint details shall conform with the requirements of Par. U-72.

(2) Stresses due to hydrostatic head shall be taken into account in determining the thickness to be used, also the total of other stresses due to loads such as the weight of the vessel, water, and distances between vessel supports, if these stresses increase the average stress over substantial sections of the shell or head by more than 10 per cent;

(3) Large temperature differentials in heads or shells shall be avoided or the effect reduced by shields or other suitable means;

(4) For heads the increased design stresses authorized by this Case may be used only for flat heads and for hemispherical or ellipsoidal heads with pressure on the concave side;

(5) The following parts shall be designed in accordance with the present rules of the Code and may be used with shells which are constructed in accordance with the rules of this Case:

(*a*) Dished heads, other than hemispherical or ellipsoidal;

(*b*) All unstayed dished heads with pressure on the convex side;

(*c*) Ellipsoidal heads with flanged-in manholes;

(*d*) All stays, braces, and parts requiring staying;

(*e*) Flanges.

(6) In determining the maximum size of an unreinforced opening under Par. U-59(*a*), the value of *K* to be used in connection with the chart in Fig. U-8 shall be 1.1 times the value of *K* computed by the formula of that paragraph for the part of the shell that contains the opening. When computing *K* by the formula in Par. U-59(*a*), the pressure *P* shall be that for which the vessel is designed, *S* shall be 1.25 times the value from Table U-2, and *t* shall be the actual full thickness of the shell at the location of the opening. Where *K* so computed is unity or greater, the maximum size of unreinforced opening shall be 2 in.

(7) Par. U-68 vessels, and those Par. U-69 vessels that are required to be stress-relieved, constructed under these alternate rules shall be stress-relieved in accordance with Par. U-76 with the additional provision that the vessels shall be allowed to cool slowly in a still atmosphere to a temperature not exceeding 600 F.

(8) (*a*) For all Par. U-69 vessels, portions of the completed welded joints shall be examined either by spot radiographing, or by sectioning, or by a combination of both methods.

(*b*) *Spot Radiographing.* When the welded joint is to be examined by spot radiographing, the technique shall be that described in Par. U-68(*h*) and the radiograph shall comply with the standards specified in Par. U-68(*h*)(12) except as allowed under retests in (*e*).

(*c*) *Sectioning.* When the welded joint is to be examined by sectioning, the specimens removed shall be such as to provide a full cross section of the welded joint and may be removed by trepanning a round hole or by any equivalent method.

Cylindrical specimens or those not having a plane surface shall be sectioned across the welds to obtain plane surfaces which shall include the full width of the weld. The plane surfaces shall be polished to a bright, smooth condition which may be accomplished by filing or grinding, and polishing with emery cloth and should be completed with the use of emery cloth of grade 00. The specimen shall then be etched by any method or solution which will reveal the defects without unduly exaggerating or enlarging them (See Par. UA-85).

Sections removed from the welded joint shall show neither cracks nor lack of fusion. Gas pockets and slag inclusion shall be permissible only:

(I) When there is slag inclusion between layers, substantially parallel with the plate surface and which is not more than one half the width of the weld metal;

(II) When there is slag inclusion across the thickness of the plate not more than 10 per cent of the thickness of the thinner plate;

(III) When there are gas pockets that do not exceed $^1/_{16}$ in. in greatest dimension and when there are no more than six gas pockets of this maximum size per square inch of the weld metal or where the combined areas of a greater number of pockets do not exceed 0.02 sq in. per square inch of weld metal.

Openings resulting from the removal of specimens may be closed by any method approved by the authorized inspector. Some acceptable methods for closing openings resulting from sectioning are given in Par. U-78(*g*).

(*d*) At least one spot shall be examined in each vessel except that when there are a number of similar vessels, each having less than 50 ft of welded longitudinal and circumferential joints, built at the same time and under the same specifications,

one examined spot for each 50 ft or fraction thereof will suffice; two spots shall be examined in vessels having more than 50 ft of welded joints; and three spots shall be examined in vessels having more than 100 ft of welded joints. If more than one welding procedure is used or if more than one operator does the welding, at least one spot shall be examined for each procedure and for each operator.

The authorized inspector shall designate the spots on the welded joints to be examined.

(*c*) *Retests.* (I) *Radiography.* When a spot has been examined by radiography and the welding does not comply with the quality requirements referred to in (*b*), but does comply at least with those defined in (II), two additional radiographs shall be taken at locations indicated by the inspector. If either of the two additional radiographs fails to meet the standards described in (II), the full lengths of all the main seams shall be radiographed and all defects not permitted in (II) shall be chipped out, rewelded, and reradiographed.

Should the first spot radiograph fail to meet the minimum quality requirements described in (II), the full lengths of all the main seams shall be radiographed and all defects not permitted in (II) shall be chipped out, rewelded, and reradiographed.

(II) Welds, in which radiographs show elongated slag inclusions, cavities, or lack of fusion, shall be unacceptable if the length of any such imperfection is greater than $^2/_3$ *T*, where *T* is the thickness of the thinner plate weld. If several imperfections within the above limitations exist in line, the welds shall be judged acceptable, if the sum of the longest dimensions of all such imperfections is not more than *T* in a length of 6*T*, and if the defects are separated by at least 6*L* of acceptable weld metal, where *L* is the length of the shortest imperfection. The maximum length of acceptable defect for any plate thickness shall be $^3/_4$ in. Any defect shorter than $^1/_4$ in. shall be acceptable for any plate thickness. The maximum permissible porosity shall be that prescribed for Par. U-68 vessels, except that not more than twice as many cavities or slag inclusions, but of no greater size, shall be permitted within any single square inch of film area, or for the whole film area.

(III) *Sectioning.* When a spot has been examined by sectioning and the welding does not comply with the minimum quality requirements defined in (*c*), two additional specimens shall be cut at intervals to be determined by the inspector, on each side of the defective specimen. If either of the additional specimens is found to be not acceptable, then more may be cut at intervals to be determined by the inspector, until the limit of the defective welding has been definitely established; or the vessel may be rejected. All welding within the definitely established limits of the defective welding shall be chipped or melted out, rewelded, and resectioned.

As an alternative, two additional spots may be examined by radiography in compliance with (*e*)(I) and (II) instead of further sectioning

(*B*) In the determination of thicknesses for internal pressure of ferrous tubes and pipes, the design stresses in Tables U-2 and U-4 may be multiplied by 1.25 for use in the formula in Par. U-20(*e*).

(*C*) For the chrome-nickel materials covered by Case No. 897, the increased stresses and joint efficiencies are permitted up to a temperature not to exceed 900 F, but within the other temperature limitations of that Case.

(*D*) Pars. U-68 and U-69 vessels constructed in accordance with the requirements of this Case and other applicable Code rules are considered safe and shall be stamped in accordance with Par. U-66, the Code symbol to be followed by the letter "A," which also shall be shown on the manufacturer's data report

CASE No. 1011

This Case, as it appeared in July, 1944, MECHANICAL ENGINEERING, has been approved and may now be considered as effective. It will appear in printed form in the interpretation pages.

CASE No. 1013

(*Interpretation of Par. P-198*)

Inquiry: In the construction of vertical fire-tube boilers under the Code rules, may a ring of plate material be substituted for the forged or cast mud ring, provided the plate material is attached as shown in Fig. P-21(*f*) and the welding is stress-relieved?

Reply: While the rules in Par. P-198 and the construction shown in Fig. P-21(*f*) were not originally intended to apply to such construction, it is the opinion of the Committee that the intent of the Code will be met if such a plate ring is attached under the provisions of this paragraph, provided the maximum width of the waterleg does not exceed 4 in., and the minimum thickness of the closure plate ring is not less than $^1/_2$ in.

Courtesy Food Machinery Corporation

INFANTRY GOING INTO "WATER BUFFALO" RAMP TANK

A.S.M.E. NEWS

And Notes on Other Engineering Activities

E.C.P.D. Report on Technical Institutes Outlines Scope and Minimum Requirements

IN the report of the actions of the A.S.M.E. Council at the meeting of June 18 and 19 (see MECHANICAL ENGINEERING for August, page 554)it was announced that at the request of the Engineers' Council for Professional Development the A.S.M.E. Council authorized the E.C.P.D. to undertake a survey of technical institutes under the direction of the E.C.P.D. Committee on Engineering Schools. The action was based on the report of the E.C.P.D. Subcommittee on Technical Institutes, a convenient summary of which is quoted from *Electrical Engineering* of July, 1944.

The report, which was subsequently submitted to the various engineering societies for their action, describes the scope of technical-institute education and suggests minimum requirements and recommendations as to how they may be effected.

Purpose of Program

As defined in the report, the purpose of these technical education programs is to prepare individuals possessing a high-school education or the equivalent for positions auxiliary to but not in the field of professional engineering. The work is essentially technological in nature, including virtually the entire range of engineering and technical industrial practice, and the programs verge upon skilled craftsmanship at one end of the scale and approach professional engineering practice at the other. Courses are more intensive and specific in purpose than are the collegiate engineering curricula, and in duration range from a few weeks to two or three years of full-time day-school or five or six years of evening-school attendance.

Industry Needs Technical-Institute Graduates

From a number of independent studies of technical-institute education, the subcommittee ascertained a need in industry for at least three times as many graduates from technical institutes as for those graduating from four-year engineering-college courses. Since the output of the technical institutes falls far short of this number and since the needs of industry must be served, many engineering graduates are employed for positions requiring less expensive and less fundamental training than that provided by the degree-conferring college.

Then, too, laws governing the registration of engineers do not recognize technical-institute graduation in evaluating education qualifications for licensure. Accrediting procedures do not include the technical institutes, and their graduates therefore receive no official credit for a program of study that has prepared them adequately for service in numerous technical positions.

Tentative Statement of Qualifying Requirements

In view of these facts the committee recommended that both industry and the engineering profession act, in their own interests if for no other reason, to place technical-institute education on a proper basis of quality and magnitude in the United States. Because of the diversification of programs in the various schools operating in the technical-institute field, it was suggested that each one, within stated boundaries, be judged on its own merits as to quality, and that each should be recognized and accredited in terms of its own purposes, scope, duration, and content. However, since some qualitative limits must be established within which acceptable programs must fall, the following requirements were advanced as a tentative statement of qualifications that all programs must satisfy in order to be considered:

1 Duration: Not less than one academic year of full-time work, or the equivalent in part-time work.

2 Requirement for admission: High-school education or the equivalent.

3 Curricula: Technological in nature, employing the application of physical science and the techniques of mathematics to the solution of practical problems, and comprising a perscribed sequence of related courses with a reasonable amount of elective subject matter.

4 Instruction: By accepted class, laboratory, or correspondence methods.

5 Teaching staff: Qualified as to education and experience.

6 Educational institution: An organized school or a division of an institution devoted to the specific aim of education of the technical-institute type; a stable organization with adequate financial support.

7 Physical facilities: Adequate for the program offered.

The subcommittee further recommended that recognition or certification of educational programs of the technical-institute type be initiated by the E.C.P.D. since it is the only agency of the engineering profession which has the status, backing, and public recognition necessary to insure acceptance of such certification. Power should be vested in an accrediting group which would include representatives of the institutes themselves and of the industries served by them.

Actions of A.S.M.E. Executive Committee

At Meeting Held at Headquarters, July 21, 1944

A MEETING of the Executive Committee of the Council of The American Society of Mechanical Engineers was held at the Society headquarters on July 21, 1944. There were present: R. M. Gates, chairman; A. C. Chick, D. W. R. Morgan, and A. R. Stevenson, Jr., of the Committee; W. G. Christy and R. F. Gagg, of the Council; J. J. Swan and G. L. Knight (Finance); W. M. Sheehan (Professional Divisions); F. G. Switzer (Meetings and Program); E. G. Bailey (Engineering Opportunities); N. H. Memory (Employment Clearing House); C. E. Davies, secretary; and Ernest Hartford, executive assistant secretary.

The following actions taken by the Committee are of general interest:

Research Committee

Approval was voted of the extension to March 1, 1945, of the contract between the Society and U. S. Army Ordnance for the research on the forging of steel shells, and to June 1, 1945, of the contract for the research on demolition bomb bodies.

Furnace Performance Factors

Approval was voted of the renewal of the co-operative agreement between the Department of the Interior, for the Bureau of Mines, and the Society, for the Research Committee on Furnace Performance Factors. This agreement covers an investigation of ash and slag in boiler furnaces and the external corrosion of furnace wall tubes.

Cincinnati Meeting Postponed

Owing to transportation congestion and at the request of the Office of Defense Transportation, the Executive Committee voted to cancel the 1944 Fall Meeting of the Society that had been scheduled for Cincinnati, Ohio, Oct. 2–5.

Committee Reports

Progress reports of the Committee on Employment Clearing House, Committee on Engineering Opportunities, and Committee on Status of Engineers were noted.

Properties of Gaseous Mixtures

Approval was voted of the appointment of E. G. Bailey, A. G. Christie, and Harvey N. Davis to constitute a committee to prepare a

program for the standardization of properties of gaseous mixtures for gas turbines.

Scholarship Fund

A scholarship fund based on contributions received from dues-exempt members was approved and administration of the scholarships established was accepted.

Group Delegates' Conferences

A tentative schedule of Group Delegates' Conferences was reported. Council representatives were designated as follows:

Group I, Hartford, Conn., Sept. 8–9, W. J. Wohlenberg, Council representative.

Group II, New York, N. Y., Sept. 13–14, R. F. Gagg, Council representative.

Group III, Philadelphia, Pa., Sept. 15–16, D. W. R. Morgan, Council representative.

Group IV, Atlanta, Ga., Sept. 22–23, Roscoe W. Morton, Council representative.

Group V, Akron, Ohio, Oct. 6–7, A. E. White, Council representative.

Group VI, Peoria, Ill., Sept. 28–29, W. A. Hanley, Council representative.

Group VII, Los Angeles, Calif., Oct. 13–14, J. Calvin Brown, Council representative.

Group VIII, Dallas, Texas, Oct. 9–10, J. A. Noyes, Council representative.

Co-Operation With Civil Service Commissioners

The Committee noted a letter addressed to J. Calvin Brown by the Civil Service Commissioners of Los Angeles, suggesting that the Society appoint a civil service committee to assist local civil service commissions in raising the standards of examination procedures for public personnel. It was voted to request the Southern California Section to appoint such a committee.

Leave of Absence

Extension was voted of the leave of absence of Clifford B. Le Page, assistant secretary, for three months part time for continuation of services on the simplification work in Washington.

Deaths

The deaths were reported of Edward N. Trump, honorary member and past-vice-president (June 21, 1944), and Walter A. Jessup, president, Carnegie Foundation for the Advancement of Teaching.

Appointments

The following appointments were approved:

Power Test Code Committee No. 10 on Centrifugal and Turbo-Compressors and Blowers, B. K. Erdoss.

Special Research Committees: Forging of Steel Shells, M. S. Evans; Demolition Bomb Bodies, J. M. Hopkins; Critical-Pressure Steam Boilers, C. L. Clark.

Special Standards Committee on Steam Turbines, A. L. Penniman, to serve as acting chairman in absence of K. M. Irwin, chairman (abroad on government work).

Freeman Fund Committee, Warren H. McBryde.

Committee on Kilgore Bill, A. G. Christie, chairman, R. L. Sackett, secretary, J. H. Herron, and Ezra B. Whitman.

E.C.P.D. Representative, James W. Parker (reappointment, 3-year term).

Georgia School of Technology, Inauguration of President Blake R. Van Leer, July 7, J. W. Eshelman.

Copies Available A.S.M.E. Constitution, By-Laws, and Rules

A LIMITED edition of the Constitution, By-Laws, and Rules of The American Society of Mechanical Engineers, amended to July, 1944, has been run. Copies are available to members of the Society upon request to headquarters, 29 West 39th Street, New York 18, N. Y.

A.S.A. Stripper-Bolt Standard Now Available

THE American Standards Association has just approved a supplement to the American Standard, Socket Set Screws and Socket Head Cap Screws, B18.3-1936. The supplement (B18.3a-1944) gives dimensions of stripper bolts (hexagonal and fluted-type socket-head shoulder screws) in eight nominal sizes ranging from $^1/_4$ to $1^1/_4$ in. It was developed by a committee under the technical leadership of The American Society of Mechanical Engineers and the Society of Automotive Engineers and may be obtained for 10 cents from the American Standards Association, 29 West 39th Street, New York 18, N. Y.

S.E.S.A. to Meet at Cleveland, Oct. 17–20

THE fall meeting of the Society for Experimental Stress Analysis will be held at the Carter Hotel, Cleveland, Ohio, Oct. 17–20, inclusive, during the week of the National Metal Congress.

Inquiries should be addressed to the Society for Experimental Stress Analysis, Box 168, Cambridge 39, Mass.

A.S.H. & V.E. Elects S. H. Downs President

THE American Society of Heating and Ventilating Engineers has elected as its president Sewell H. Downs, member A.S.M.E., for 20 years chief engineer of the Clarage Fan Company, Kalamazoo, Mich.

Institute of Metals Has New Secretary

ANNOUNCEMENT has been made of the retirement, on June 30, of G. Shaw Scott from the secretaryship of The Institute of Metals (London). Mr. Scott has held the pots for the past 36 years. He will be succeeded by K. Headlam-Morley, who will continue to act also as secretary of The Iron and Steel Institute.

H. M. Blank Elected President of Columbus Technical Council

AT a meeting held on June 13, 1944, the Columbus Technical Council was formally organized. Representatives of eight technical and scientific societies adopted the constitution and elected officers for the coming year. H. M. Blank, representing the A.S.M.E., was elected president, R. W. Stitt, American Welding Society, vice-president, and R. W. Miner, A.I.E.E., secretary-treasurer. E. J. Lindahl, Junior Member A.S.M.E., was selected as chairman of the Publication Committees of the Council. The purpose of the Council is to coordinate the efforts of the individual scientific groups.

"Creative Engineering" Papers Available

PAPERS on ingenuity presented at the 1942 and 1943 Annual Meetings of the A.S.M.E. under the auspices of the Committee on Education and Training for the Industries have been collected into one pamphlet under the general title of "Creative Engineering" and are now available for sale.

These pamphlets will cost fifty cents for individual copies (please send stamps). Quotations will be given for reprints in quantities by addressing your inquiry to the publication sales department, A.S.M.E. headquarters, 29 West 39th Street, New York 18, N. Y.

Keyes Succeeds Davis as O.P.R.D. Director

THE appointment has been announced of Dr. Donald B. Keyes as director of the W.P.B. Office of Production Research and Development, to succeed Dr. Harvey N. Davis, past-president A.S.M.E., who will devote full time to his duties as president of the Stevens Institute of Technology.

King Paper Price Revision

THE price of the reprints of the article by W. J. King, "The Unwritten Laws of Engineering," has been revised. Single copies are now priced at twenty-five cents.

A.S.M.E.-A.I.M.E. Joint Fuels Conference, at Charleston, West Va., Oct. 30-31

AS a result of the efforts of the Office of Defense Transportation to eliminate unnecessary travel, the usual annual joint meeting of the Fuels Divisions of the A.S.M.E. and the Coal Division of the A.I.M.E. will be "localized." The meeting dates are October 30 and 31.

The program itself will be prepared by the Executive Committee of the Fuels Division and it is believed that any persons who are able to attend this meeting without complicating travel conditions in the country will find an interesting and adequate program of papers and events awaiting them.

Those interested in further details of the meeting may obtain more detailed information concerning the program by writ ng to the Secretary of the A.S.M.E. at headquarters.

President's Page

Active Committees—An Active Society

THE A.S.M.E. was organized sixty-four years ago for the service of its members to our profession and to society. The scope of its activities has been widened through the years. However successful we may have been in discharging our duties and in making constructive contributions in the past, our responsibilities and opportunities were never before so great as they are today.

How can we use the talents of our 18,000 members to meet this challenge? It is obvious that we cannot all meet at one time to perform our duty; we must do the major part of the work of our Society through our committees.

It is by the activity of our committees and the quality of their membership that the progress of the Society is largely determined. This is true of the A.S.M.E. as it is of any large organization.

More than 1500 of our members are serving on our national committees. These include our Council, our standing committees, our technical committees, our professional divisions, and numerous subcommittees. There are also the seventy local sections and one hundred and twenty student branches with their executive committees and subcommittees. Altogether, over fifteen per cent of the total membership may be so engaged. What about the assignment to duty of the other eighty-five per cent, or that part of them available, to take an active part in society work?

Normally, about one fifth to one third of the membership of each committee is changed each year. This gives an opportunity for introducing new personalities, new ideas, new energy, new leadership. In a membership so large, so widely distributed geographically, it is difficult to know members who have the qualities that are most desired and most needed.

The challenge to our profession, to our Society in the years ahead, will be met, if it is met, by the younger engineers who are now coming into or approaching the period of their maximum professional energy and activity. We want them on our committees, and the most able of our junior members also as junior observers.

We must depend upon each member of the Society, each committee, each section, and each division to bring before the chairmen of the committees or the Executive Committee of the Council the names of the persons best qualified for committee service.

(*Signed*) R. M. GATES, *President, A.S.M.E.*

Among the Local Sections

Southern California Section Holds Dinner Meeting

"The Gas Turbine—Its Characteristics and Potentialities," was the subject discussed by J. Kenneth Salisbury, guest speaker at a dinner meeting of the Southern California Section held on July 18. Mr. Salisbury was well qualified to present this topic, since he is an outstanding engineer in the development of the gas turbine for the General Electric Company, Schenectady, N. Y.

J. K. Salisbury Speaks at Joint Colorado Meeting

At the July 6 meeting of the Colorado Section, held jointly with the members of the A.I.E.E., in the Oxford Hotel, Denver, Colo., J. K. Salisbury spoke on the characteristics and potentialities of the gas turbine. Mr. Salisbury, who is connected with the Turbine Engineering Division of the General Electric Company, Schenectady, N. Y., presented an excellent talk, reviewing briefly the history of the gas turbine, with illustrations depicting fuel economies, effect of temperature, efficiency, compression ratio, and speed. A discussion period concluded the lecture.

Pipe Line "Big Inch" and "Laminated Plastics" Are Subjects at New Haven

On March 21, the New Haven Section met to hear the world's largest pipe line, popularly known as the "Big Inch," discussed by A. B. Frost of the Allis-Chalmers Company, Milwaukee, Wis. Mr. Frost's talk, which was illustrated by lantern slides, described pumping stations in detail. Two animated cartoons depicted steam generation. This Section met again on April 17, when the development of various grades of laminated and other plastics, together with their physical properties, were outlined by Eugene R. Perry of the Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa. Mr. Perry showed numerous samples of plastic products, ranging from ball-bearing retainers to bomb holders.

Gas-Turbine Usages Outlined at Utah Section

The gas turbine is particularly adaptable for use in locomotives because of its light weight, low cost, ease of assembly, and smooth flow of power and may replace the Diesel engine, J. K. Salisbury of the Turbine Engineering Division, General Electric Company, Schenectady, N. Y., said at a public lecture sponsored by the Utah Section and members of the A.I.E.E., on July 10. The meeting was held in the Newhouse Hotel, Salt Lake City, Utah, with approximately 50 members and guests in attendance.

With the Student Branches

Cornell Elects New Officers

CORNELL BRANCH met on June 23 for the main purpose of electing new officers. The officers elected are: Frank A. Swingle, chairman; William F. Pearson, vice-chairman; and Fred D. McNair, secretary-treasurer. Prior to the election of officers, members enjoyed an interesting motion picture on the laying of an oil pipe line, which described the many difficulties encountered, together with their solution.

DREXEL BRANCH devoted its final meeting of the Spring term on June 7, to acquaint its members with the new officers of the 1944–1945 semester, which include Burt Fisher, chairman; Tom Snyder, vice-chairman; Joe Kaufmann, treasurer; Tom Healy, recording secretary; and Lillian McFadden, corresponding secretary. Following a brief discussion pertaining to future joint meetings, members viewed the motion picture, "Football High Lights of 1944." The newly elected officers of this Branch held their first meeting on June 12, for the purpose of appointing chairmen of various committees, as follows: Elmer Goetz, membership; Boris Kudravetz, meetings; Hugh Clopp, inspection trips; and Tom Healy, publicity. A tentative schedule of meetings was also set up.

At the July 13 meeting of the MINNESOTA BRANCH, members elected officers for a four-month term, expiring November 1, 1944, as follows: D. J. Carlson, chairman; R. L. Kulp, vice-chairman; J. H. Brown, secretary; and A. Schwartz, treasurer. Program, publicity, and membership committees also were selected at this session.

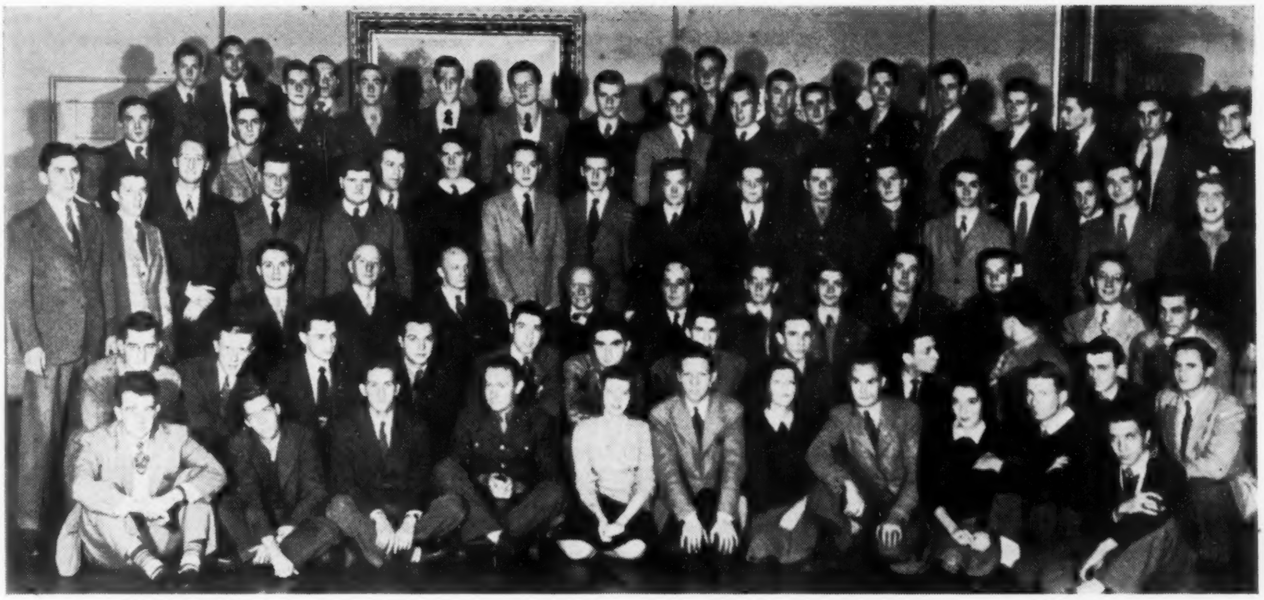
A motion pictureentitled, "Its Our Job," depicting the human element and problems existing between foremen and their subordinates, featured the June 28 meeting of the NEBRASKA BRANCH.

World War II Veteran Addresses Northeastern Branch Meeting

The featured speaker at the July 12 meeting

(*Continued on p. 625*)

A.S.M.E. METROPOLITAN SECTION SPRING ROUND-UP, APRIL 21, 1944



A.S.M.E. STUDENT BRANCH AT DREXEL INSTITUTE OF TECHNOLOGY

A.S.M.E. Group Student Meetings

GROUP I—TUFTS COLLEGE, MASS., MAY 13, 1944, TUFTS COLLEGE

Attendance: 126 — Papers presented: 4

Prize	Recipient	Title of Paper	College
First	William C. Cooley	New Horizons in Aviation	Massachusetts Institute of Technology
Second	Alfred S. Harding	Economic Position of the Engineer	University of New Hampshire
Third	Harry M. Sheketoff	Performance Tests on C.F.R. Engine	University of Connecticut
Old Guard	Arthur L. Chase	History and Development of Steam Boilers	Northeastern University

GROUP III—NEW YORK, N. Y., APRIL 22, 1944, COOPER UNION

Attendance: 150 — Papers presented: 6

Prize	Recipient	Title of Paper	College
First	Stanley Handman	Testing of Rocket Engines	Polytechnic Institute of Brooklyn
Second	Carl Gans	Biomechanics	New York University
Third	Victor Cole	The Design of a Jib Crane	New York University
Old Guard	Jack Heller	Problem in Modern Aerodynamics—The Shock Wave	Polytechnic Institute of Brooklyn

GROUP V—BALTIMORE, MD., APRIL 21, 1944, JOHNS HOPKINS UNIVERSITY

Attendance: 116 — Papers presented: 7

Prize	Recipient	Title of Paper	College
First	Paul Arthur	Optimum Compression Ratios for Diesel Engines	University of Maryland
Second	Spencer Flournoy	Connecticut Valley Power Exchange	Johns Hopkins University
Third	Hugh Evans	Hydraulic Control of Naval Airplane Cranes	Duke University
Old Guard	Robert Lucia	Air Compressors	Catholic University of America

GROUP VII—DETROIT, MICH., APRIL 22, 1944, UNIVERSITY OF DETROIT

Attendance: 45 — Papers presented: 3

Prize	Recipient	Title of Paper	College
First	Melvin H. Lill	Problems in Rocket Engineering	Michigan State College
Second	A. Victor Peterson, Jr.	Physical Characteristics of Metals at High Temperature	University of Michigan
Old Guard	John J. Sazynski	The Construction of a Slide Rule	University of Detroit

(Continued on page 624)

(*Continued from page 623*)

GROUPS VIII—XI—XII—CHICAGO, ILL., APRIL 14–15, ILLINOIS INSTITUTE OF TECHNOLOGY CO-OPERATING WITH NORTHWESTERN UNIVERSITY

Attendance: 222 Papers presented: 9

Prize	*Recipient*	*Title of Paper*	*College*
First	William W. Wachtl	Instrumentation in Diesel Combustion	University of Wisconsin
Second	John H. Colby	Rocket Projectiles	Purdue University
Third	Gilbert H. Peirce	Gas Turbine as High-Speed Postwar Locomotive	Marquette University
Fourth			
Old Guard	George A. Boesel	Design of Automatic Screw Machine Cams	Rose Polytechnic Institute
Fifth	Cavour Hauser	Radiography	University of Minnesota
Sixth	Donald C. Haack	Grinding and Lapping of Plug Gages	Illinois Institute of Technology
Seventh	Gene Meyer	Effect of Tetra-Ethyl of Lead on Detonation in Spark-Ignition Engine	Northwestern University
Eighth	Edward C. Neidel	Photoelastic Stress Analysis	Illinois Institute of Technology
Ninth	James F. Gormley	Torque and Thrust Using Various Size Twist Drills	University of Notre Dame

GROUP X—IN CONJUNCTION WITH BIRMINGHAM, ALA., SPRING MEETING, APRIL 3

Attendance: 100 Papers presented: 10

Prize	*Recipient*	*Title of Paper*	*College*
First	Lewis R. Twitchell	Electrolytic Polishing of Metals	University of Florida
Second	Melvin T. Sturm	Powder Metallurgy	University of Tennessee
Third	John Cochrane	Development in Jet Propulsion	Tulane University of Louisiana
Fourth	David Kling	Plywood Aircraft Construction	University of Louisville
Old Guard	Gerard R. Pucci	Boiler Saline Concentration	Virginia Polytechnic Institute

GROUP XIII—LINCOLN, NEB., APRIL 21, 1944, UNIVERSITY OF NEBRASKA

Attendance: 42 Papers presented: 10

Prize	*Recipient*	*Title of Paper*	*College*
First	Lester F. Oborny	Limited Torque Brakes for Trucks and Trailers	Kansas State College
Second	Robert F. Maurer	Liquid Hydrocarbon Compressibility Source of Error in Metering	University of Kansas
Third	Joseph R. Wilson	Cathodic Protection of Pipe Lines	University of Kansas
Old Guard	William L. Havel	The Birds Did it First	University of Missouri

GROUP XIV—AUSTIN, TEXAS, MAY 1, 1944, UNIVERSITY OF TEXAS

Attendance: 150 Papers presented: 10

Prize	*Recipient*	*Title of Paper*	*College*
First	Marvin E. Snyder, Jr.	Porcelain Enamel, Its Manufacture and Applications	Southern Methodist University
Second	Van Rex Boyett	Basic Aircraft Layout and Proportional Intermediate Sectioning	Southern Methodist University
Third	Robert K. Kidd	The Frigid-Drum Freezer	University of Texas
Fourth	Melvin Alpern	Intergranular Corrosion of 25-20 Chrome-Nickel Weld Metal	University of Oklahoma
Fifth	Bernard W. Levy	Perfect Lubrication of Journal Bearings	Texas A.&M. College
Old Guard			
Sixth	William M. Black	A Technique of Engineering Sketching	Rice Institute
Seventh	Robert M. James	Jet Propulsion of Aircraft	University of Texas
Eighth	Robert Currie	Postwar Airports	New Mexico State College
Ninth	Patrick O. Braden	The Engineering Uses of Glass	Rice Institute
Ninth	Robert G. Cox	High-Speed Photography and Its Application to Mechanical Engineerin ;	Texas A.&M. College

GROUP XVII—SAN FRANCISCO, CALIF., FEBRUARY 26, UNIVERSITY OF SANTA CLARA

Attendance: 20 Papers presented: 3

Prize	*Recipient*	*Title of Paper*	*College*
First	Robert L. Harris	Acceleration of Ships	University of California
Second	William G. Kast	Pressure Distribution Over a Joukowski Airfoil	University of California
Old Guard	Joseph E. Lepetich	Graphical Solution of Fluid Friction Problems	University of Santa Clara

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OREGON STATE COLLEGE, JOINT MEETING WITH OREGON LOCAL SECTION, MARCH 25, 1944

Note: Not a Student Meeting, but a joint meeting of Oregon State College and Oregon Local Section because Group Student Meeting was not held.

Prize	*Recipient*	*Title of Paper*	*College*
First	John C. Boehm	The Army Specialized Training Program	Oregon State College
Second	Herbert C. Brodahl	Art and Engineering	Oregon State College
Third	H. Clifton Glover, Jr.	A Rotary Gasoline Engine	Oregon State College
Fourth	Eugene O. Lieburg	The Physics of Wood-Wind Instruments	Oregon State College

(*Continued from page 622*)

of the NORTHEASTERN BRANCH was Ernest M. Cooke, a World War II veteran and member of the junior class. Mr. Cooke gave an interesting account of his experiences while attached to the Air Corp Engineers in India, and displayed several souvenirs, among which was a ghurka knife and scabbard. Prior to Mr. Cooke's comments, members elected John Smilaek chairman of the branch, to succeed Serafin Krukonis, who has joined the armed forces.

Student Papers Presented at Yale

Three student papers presented at the July 17 meeting of YALE BRANCH were reported by the secretary of the Branch as follows: "Problems of Postwar Rehabilitation and Employment," by A. L. Linzell; "Calibration of the 'Pyrocar' and 'Teller-Brinell'," by G. K. Stringwell, and "Mathematics and Stuff," by H. M. Bowen.

Engineering Societies Personnel Service, Inc.

These items are from information furnished by the Engineering Societies Personnel Service, Inc., which is under the joint management of the national societies of Civil, Electrical, Mechanical, and Mining and Metallurgical Engineers. This Service is available to members and is operated on a co-operative, nonprofit basis. In applying for positions advertised by the Service, the applicant agrees, if actually placed in a position through the Service as a result of an advertisement, to pay a placement fee in accordance with the rates as listed by the Service. These rates have been established in order to maintain an efficient, nonprofit personnel service and are available upon request. This also applies to registrants whose notices are placed in these columns. All replies should be addressed to the key numbers indicated and mailed to the New York office. When making application for a position include six cents in stamps for forwarding application to the employer and for returning when necessary. A weekly bulletin of engineering positions open is available to members of the co-operating societies at a subscription of $3 per quarter or $10 per annum, payable in advance.

New York	Boston, Mass.	Chicago	Detroit	San Francisco
8 West 40th St.	4 Park St.	211 West Wacker Drive	109 Farnsworth Ave.	57 Post Street

MEN AVAILABLE[1]

MECHANISM DESIGN, all types, by experienced mechanical engineer. Own office. Philadelphia or New York City region preferred. Me-854.

GRADUATE MECHANICAL ENGINEER, 27. Draft 2B. Four years varied production, designing, and detailing experience. Desires responsible position in work relative to production engineering with good postwar future. Me-855.

ENGINEER-EXECUTIVE, mechanical. Twenty years' experience metallurgical and industrial plants, design, construction, operation. Many years responsible charge and executive capacity. Desires position executive capacity having postwar possibilities. Any location considered. Me-856.

MECHANICAL ENGINEER with 20 years' diversified experience; excellent background in power and process plant design, maintenance, and operation. Desires permanent position consulting or plant engineering. Prefers South. Me-857.

MECHANICAL AND ELECTRICAL ENGINEER, 25 years of research, development, and design. Speaks Russian. Now government-employed as P-4. Wishes to rejoin private industry with good postwar prospects here or abroad. Me-858.

GRADUATE MECHANICAL AND CIVIL ENGINEER, discharged Army Officer, 26, desires permanent position with reliable firm. Experienced production engineer, including plant layout, scheduling, piece rate, time studies, and efficiency. Will travel. Me-859.

[1] All men listed hold some form of A.S.M.E. membership.

POSITIONS AVAILABLE

PRODUCT ENGINEER with knowledge of all types of welding, both aluminum and steel; processing and methodizing; previous experience in sheet-metal products; drawings, designs—product and tool; stampings, dies, jigs, fixtures, assemblies and follow-up in the shop of all troubles due to drafting, product design, tool design, jigs, fixtures, etc. $6500 year. Virginia. W-4076.

MECHANICAL ENGINEERS with experience in tooling, planning, designing, production-line installations. Immediate duty will be installation and operation of shell line. $4800–$7200 year. Pennsylvania. W-4080.

ENGINEERS. (*a*) Chief production engineer, under 50. Must have mechanical-engineering degree or equivalent in special training and experience with good background of practical experience in production of wide variety of small mechanical parts. Will be responsible for all production engineering including plant layout, layout of operations for efficient production of parts, purchase of new machine tools and manufacturing equipment, tool and gage designing, tool manufacturing, time study and rate setting, and estimating costs on new work. Plant employs between 400 and 500. Permanent; good postwar opportunity. $6500 year. Prefer man with majority of experience in Middle West. (*b*) Production manager, under 43. Must have industrial engineering degree or equivalent in special training and experience. Must have successful record showing ability to organize and control all production-department functions. Will be responsible for production planning, production control, shipping, receiving, material handling, and material stores. Must be familiar with ordering of material and maintaining of stock within W.P.B. regulations. Plant employs between 400 and 500. Permanent, with good postwar possibilities. $6000 year. New York metropolitan area. W-4091.

ENGINEERS. (*a*) Maintenance engineer to direct shopwork on preventative maintenance. Several years' experience preferably in chemical industry. Will work directly under chief engineer. $5000–$6000 year. (*b*) Industrial engineer to head industrial-engineering department. Experience in process or chemical plant necessary. $5000–$6000 year. (*c*) Mechanical engineer to act as chief project engineer. Should have some experience on design, particularly in chemical plants. Work will include estimating, priorities, etc. $5500–$6000 year. Pennsylvania. W-4092.

ENGINEERS. (*a*) Engineer, 25–40, thoroughly experienced in time and motion study. Applicant must be able to get along with people. Work is in large department store and covers production and merchandise-handling problems. Permanent. Write, giving full qualifications, past experience, salary expected, and reason for leaving present position. (*b*) Engineer, young, interested in building maintenance and operation. Ability to handle people and get full co-operation of associates not under direct supervision. Willingness to work hard for long hours. Permanent job with unlimited possibilities. Write giving full qualifications, background, and salary expected. Georgia. W-4111.

ENGINEERS. (*a*) Mechanical engineer able to handle important design responsibilities connected with product development covering broad field of high-grade consumer products. Must be able to conceive and execute sound practical designs and follow through their development. Should have broad knowledge of manufacturing processes and keen realization of cost factors. (*b*) Refrigeration engineer with theoretical background and considerable practical experience in field of mechanical refrigeration. Should be able to undertake major phases of design and development of new line of refrigeration equipment. Middle West. W-4112-C.

FACTORY MANAGER, graduate mechanical engineer, experienced in precision shop production. Must be good executive and capable of directing plant of approximately 750 people. Any experience in forgings would be beneficial. $8000–$12,000 year. Upper New York State. W-4116.

ASSISTANT EXECUTIVE ENGINEER, 35–45, with background of industrial experience in manufacturing plants. General business and financial experience essential. Knowledge of Spanish desirable. $5600 year. Washington, D. C. W-4123.

DESIGN ENGINEER with background of experience in acoustical engineering, to design and plan new loud speakers of very large type. $5000–$7500 year, New York metropolitan area. W-4129.

POWER PLANT SUPERINTENDENT. Must have actually had ten years' operating experience in steam power plant. Some knowledge of Spanish necessary. Mechanical-engineering degree. $6000 year. Cuba. W-4133.

SHOP SUPERINTENDENT for large machine shop for company building presses and special machinery. Plant employs 400. Salary to $10,000 year. Northern New Jersey. W-4142.

TOOL ENGINEER capable of determining the

best method for making various types of sheet-metal products. Will be required to design all necessary tools, dies, jigs, and fixtures and either procure them from outside sources or supervise the manufacture of same in shops. Must have thorough understanding and be experienced in tooling up for the production of sheet-metal products, the designing of all tools, dies, jigs, and fixtures necessary to production of these products, as well as ability to obtain results and maintain production schedules. $6000 year. Pennsylvania. W-4143.

MAINTENANCE ENGINEER, mechanical, with some knowledge of electrical work for refrigeration, light, and power, and general maintenance on large agricultural project in Bahama Islands. Permanent. $4800–$7200 year. W-4158.

PLANT MANAGER to take general charge of operations of concern producing refrigerating and air-conditioning equipment. Employ about 50 men in machine shop. $7800 year. New York, N. Y. W-4172.

GENERAL MANAGER, 40–50, to operate small steam railroad in foreign country. Prefer foreign experience but will consider man with diversified domestic work or logging railroad experience. Salary from $8000–$10,000 year. W-4173.

SERVICE ENGINEER for foreign service, 25–35 graduate in mechanical or electrical engineering. Must have experience in manufacturing and production; operation and maintenance of machinery and equipment; purpose and application of methods and procedures, time studies and other elements of modern plant management. Company will train man. Opening on staff of foreign subsidiary of company producing hospital, surgical supplies, and pharmaceuticals. Salary open. Excellent opportunity. W-4179.

PLANT ENGINEER, 30–45, graduate mechanical, for spinning and weaving plant. Will be responsible for general direction of mechanical department and principal function will be improvement of service and quality, and reduction of cost of maintenance, power, and related problems. Must have experience like responsibility in industrial plant; textile experience preferred but not essential. $5000–$6000 year. New England. W-4180.

Candidates for Membership and Transfer in the A.S.M.E.

THE application of each of the candidates listed below is to be voted on after September 25, 1944, provided no objection thereto is made before that date, and provided satisfactory replies have been received from the required number of references. Any member who has either comments or objections should write to the secretary of The American Society of Mechanical Engineers immediately.

KEY TO ABBREVIATIONS

Re = Re-election; Rt = Reinstatement; Rt & T = Reinstatement and Transfer to Member.

NEW APPLICATIONS

For Member, Associate, or Junior

ADAMS, EARL E., New York 28, N. Y. (Rt)
ASTON, G. F., Portland, Oregon (Rt)
BADEAU, CARROLL A., Elizabeth 1, N. J.
BALLENGER, ROBERT D., Atlanta, Ga.
BARTOW, PAUL L., St. Petersburg, Fla.
BLANCHARD, WALTER P., West Lynn, Mass.
BOWEN, JOHN THOMAS, Pasadena, Calif.
BRIE, EMILE H., Fort Belvoir, Va.
BUCHER, GEORGE H., Pittsburgh, Pa.
BULLWINKEL, HERMAN HENRY, Chicago 80, Ill.
BUOTE, CLARENCE E., Pawtucket, R. I.
BYRNE, THOMAS H., Los Angeles 4, Calif.
CAMPBELL, FRANK D., Chicago 20, Ill. (Rt)
CARTINHOUR, JOHN, New York, N. Y.
CRONE, J. M., Buffalo 5, N. Y.
DALY, GEORGE F., Endicott, N. Y.
DANIELS, FREDERICK A., Herkimer, N. Y.
DYM, JOSEPH B., E. Pittsburgh, Pa.
ETTINGER, JACOB, New York, N. Y.
FLEISCHMANN, WALTER L., Fort Wayne 6, Ind. (Rt & T)
FREY, CHARLES A., Camden, N. J.
FRY, ALFRED G., Philadelphia 35, Pa.
GELLMAN, ALLEN B., Chicago, Ill.
GLIDEWELL, J. E., Berkeley 7, Calif.
GRIFFIN, JOS. F., East Chicago, Ind.
GRISSY, W. A., Cambridge, Mass.
GROSSER, CHRISTIAN E., Cambridge, Mass.
HALLAS, LEON G. E., Alton, Ill.
HARTLEY, A. C., London, E.C.2, England
HINDLE, NORMAN F., Calumet City, Ill.
HOLLOWAY, ROBERT ALLEN (ENSIGN), Long Beach 4, Calif.
JAHNCKE, PAUL F., New Orleans 15, La.
JOHNSON, G. DUGAN, York, Pa.
KERR, J. L., Lynn, Mass.
LANSING, JAMES H., Cleveland, Ohio
LENIHAN, THOMAS J., JR. (ENSIGN), Bremerton, Wash.
LITTLETON, NORMAN G., Corning, N. Y.
LONG, WILBUR O., Arcadia, Calif.
LOW, JOHN J., Los Angeles, Calif.
MANDERFIELD, ROBT. E., Detroit, Mich.
MCALEXANDER, A. W., Chickasaw, Ala.
MCKINNEY, RUSSELL E., Detroit, Mich.
MEADE, H. E., New Orleans, La.
MOORE, MARK B., Swarthmore, Pa.
MULLEN, ROBERT M., Pittsburgh 14, Pa. (Rt & T)
MURDOCK, O. V., Portsmouth, Va.
NEILON, C. R., Houston, Texas
OBERG, DAVID P., Redwood City, Calif.
O'DONOGHUE, J. G., Clifton, N. J.
OSBORNE, HARRY J., Elgin, Ill.
PENLEY, B. S., Chicago 51, Ill.
PHILLIPS, A. J., Windsor, Conn.
PIPER, FRED F., JR., New Kensington, Pa.
POWERS, MICHAEL M., Granville, Ohio
REA, RALPH G., Robinson, Ill.
RUSSELL, THOS. F., Chicago, Ill.
SCHINDLER, A. J., Salt Lake City, Utah
SCHNEIDER, OTTO, Forest Hills, N. Y.
SHANLEY, F. R., Los Angeles 28, Calif.
SHERRILL, B. E., Atlanta 2, Ga.
SHIELDS, JULIAN W., Pelham, N. Y.
SLOAN, ROBERT S., JR., Decatur, Ga.
SMITH, ELMER, Owensboro, Ky.
SMITH, LE ROY F., Bergenfield, N. J.
SMITH, RICHARD B., Scranton 9, Pa.
STAPLES, ARTHUR J., Worcester 2, Mass. (Rt & T)
STERN, GEORGE J., Alhambra, Calif.
STORK, ALFRED H., Douglaston, N. Y. (Rt)
SUTHERLAND, ROBERT A., Chicago 6, Ill.
SZEKELY, ERNEST, Wauwatosa 13, Wis.
THORNLEY, ALBERT E., Pawtucket, R. I.
TURTON, JAMES G., New York, N. Y. (Rt)
UNGER, PAUL R., Chicago 24, Ill.
VAN DRIEST, EDW. R., Cambridge, Mass.
WITMER, GUY W., Baton Rouge, La.
WHITTEMORE, W. M., Diablo Heights, C. Z.
ZARUBA, FRANK K., Brooklyn, N. Y.
ZOLLER, R. E., London, N. 21, England

CHANGE OF GRADING

Transfer to Follow

MOODY, LEWIS F., Princeton, N. J.

Transfers to Member

BALLMAN, HARRY C., Cincinnati 2, Ohio
KALKHOFF, AMOS W., Chicago Heights, Ill.
PERRIN, ARTHUR M., Brooklyn, N. Y.
TAYLOR, IRVING, Mamaroneck, N. Y.

Necrology

THE deaths of the following members have recently been reported to headquarters:

CARMICHAEL, ANDREW J., June 19, 1944
CHAPMAN, CLOYD MASON, July 2, 1944
GRISWOLD, H. J., December 13, 1943
HAGAR, ARTHUR P., June 15, 1944
HATHAWAY, KING, June 12, 1944
KING, KENNETH JACOB, April 24, 1944
KOPF, EMIL A., May 22, 1944
LEISEN, THEODORE ALFRED, July 18, 1944
MILLER, WILLIAM DUNN, July 19, 1944
MULLER, RICHARD O., June 4, 1944
MURRAY, WARREN E., December 30, 1943
PEIRCE, WILLIAM HENRY, May 25, 1944
PURDY, GEORGE C., July 2, 1944
QUIGLEY, WIRT S., July 16, 1944
ROY, EUGENE H., June 17, 1944
TRUMP, EDWARD N., June 21, 1944
WOOD, DENNISTOUN, July 12, 1944

A.S.M.E. Transactions for August, 1944

THE August, 1944, issue of the Transactions of the A.S.M.E. contains:

Theoretical Regenerative-Steam-Cycle Heat Rates, by A. M. Selvey and P. H. Knowlton
Mechanical Features of the Glenville Impulse Turbine, by Arnold Pfau
Efficiency Analysis of Pelton Wheels, by Robert Lowy
Range of Operation of Steam Plants in a Combined System of Steam and Hydro, by A. T. Hutchins and Howard Duryea
The Co-Ordinated Operation of Hydro and Steam Capacity in Electric Power Systems, by G. W. Spaulding
Evaluating Importance of the Physical and Chemical Properties of Fly Ash in Creating Commercial Outlets for the Material, by C. M. Weinheimer
Radio-Frequency Technology in Wood Application, by G. F. Russell and J. W. Mann